


<b>BOSCH</b> 	<b>Application Note</b> BlueBox Demo-Board for the digital sensors SMB365 (acceleration) and SMD500 (pressure)	Bosch Sensortec AN18002
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# Installation and use of the BOSCH Sensortec multi sensor, wireless Demo-Board BlueBox V1.0

## **ABSTRACT**

Based on the experience of 500 million MEMS sensors and testing to highest quality standards, BOSCH Sensortec has developed a sensor family, consisting out of pressure- and acceleration sensors with best-of-the-market performance and outstanding reliability. Both the SMB365 acceleration sensor and the SMD500 pressure sensor are specifically designed for digital low-power applications to enhance functionality in consumer electronic devices as well as in health, logistics and security systems. These sensors are available in small and thin standard packages (QFN 4x4 mm<sup>2</sup> for acceleration and LCC8 5x5 mm<sup>2</sup> for pressure) to fit even into the smallest, state-of-the-art devices.

This application note shows how to set up and how to install the SensorDesktop software and the BlueBox hardware for functionality demonstration and some minor evaluation purposes or application examples of the SMB365 and the SMD500 sensor. The proper use and some general functions, e.g. wireless operation of the BlueBox Demo-Board, are also described. For specific product evaluation refer to the BOSCH Sensortec Evaluation Board which is especially designed for application engineering or extensive testing purposes.

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**REQUIREMENTS**

- IBM-compatible PC (min. 1.5 GHz and 128 MB RAM)
- Operating system: Windows2000® or WindowsXP®
- Bluetooth capability including software and drivers for optional wireless operation <sup>1)</sup>
- CD-ROM Drive
- Temporary administrator rights to install software
- Free USB 1.1 Port or higher for wire bounded operation


**OPERATING CONDITIONS:**

- Temperature: 0 – 55°C

1) The Bosch Sensortec BlueBox with its Sensor Desktop software package supports full wireless operation via Bluetooth. The Bluetooth capability is specific to the operating system. All additional necessary hard- and software (e.g. Bluetooth stick with its corresponding software and drivers) is not included in the BlueBox multi sensor wireless demo board scope of delivery.

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## 1 Introduction

Sensors from Bosch Sensortec provide many capabilities for consumer products, offering a wide range of new functions. By measuring acceleration, pressure and angular rate, they make operating devices simpler and more intuitive. BOSCH Sensortec MEMS sensors also contribute to more efficient medical care. Devided into acceleration and pressure sensing, the applications are typically realized in the fields of

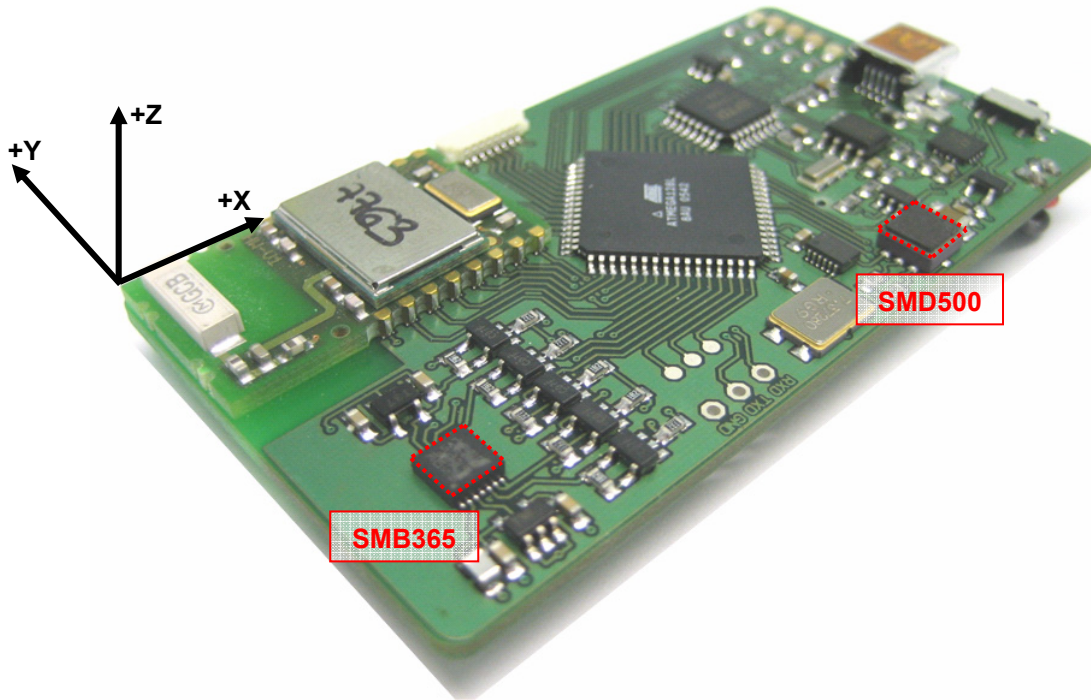
### Acceleration Sensing

- Mobile phones and PDAs
- Portable music players
- Toys and gaming
- Portable city- and outdoor navigation
- Leisure and sports
- Camera and video equipment
- Mobile computing
- Security systems
- Health
- Home appliances
- Logistics

### Pressure Sensing:

- Portable city- and outdoor navigation
- Dead reckoning
- Leisure and sports
- Weather forecast
- Vertical velocity indication (rise / sink speed)
- Security systems


## 1.1 Board overview



[1.1] BlueBox overview including axes alignment for SMB365 acceleration sensor

The Bosch Sensortec BlueBox Demo-Board in combination with its SensorDesktop software was built for the simultaneous demonstration of the general functionality of the digital accelerometer sensor SMB365 and the digital pressure sensor SMD500. This includes the possibility of demonstrating output signal behaviors of each sensor as graphical functions, interrupt features different power modes, threshold and hysteresis limits, different acceleration or pressure ranges, the self test function, as well as a user defined direct data export. All either wire bound via USB or wireless via Bluetooth. Note that the Bosch BlueBox Demo-Board should not be considered as an evaluation tool. For specific product evaluation refer to the corresponding BOSCH Evaluation Kits.

After a simple installation of the SensorDesktop software and the connection of the demo board to a free USB port acceleration specific signals corresponding e.g. to tilt, movement, free-fall, vibration, shock as well as pressure specific signals corresponding e.g. to height, atmospheric

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or differential pressure, change in weather and many more can all be measured and visualized in real-time.

#### 1.1.1 Acceleration Part (SMB365)

In order to measure the above mentioned acceleration specific signals, the BlueBox demo board is equipped with the Bosch Sensortec SMB365 acceleration sensor. This digital, triaxial accelerometer, on the basis of the differential capacitive principle, is able to measure low gravity accelerations in two ranges ( $\pm 2g$  and  $\pm 10g$  full scale) in all 3 directions in space, the X, Y and Z direction with a resolution of 0.004g in the low g range. The alignment of the positive X, Y and Z direction according to the acceleration sensor is described in the illustration [1.1] above. The SMB365 is based on automotive proven Robert Bosch technology for silicon surface micro-machining processes. This has been proven in more than 200 million Bosch accelerometers so far.

#### 1.1.2 Pressure Part (SMD500)

Additionally to the accelerometer, the BlueBox board is equipped with another Bosch Sensortec product, the SMD500 pressure sensor, which marks a new generation of high precision digital pressure sensors for consumer applications. The SMD500 is based on piezoresistive technology for EMC robustness, high accuracy and linearity as well as long term stability. Its ultra low-power, low voltage electronics are optimized for use in mobile phones, PDAs, GPS devices and outdoor equipment. With an altitude noise down to 0.03 hPa (0.25 m) it offers superior performance in a measurement range from 300 to 1100 hPa (+9000 to -500 m).

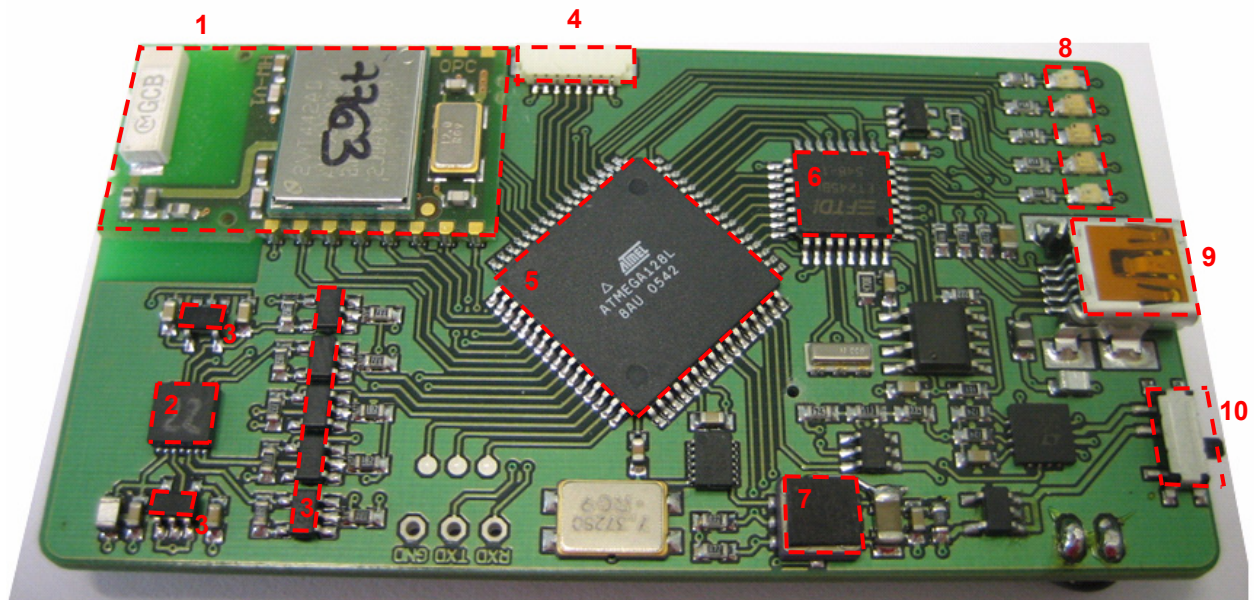
For detailed information please refer to the SMB365 and SMD500 related data sheets.

**1.2 Board constituents**

The following illustration describes the main elements of the BlueBox multi sensor demo board.

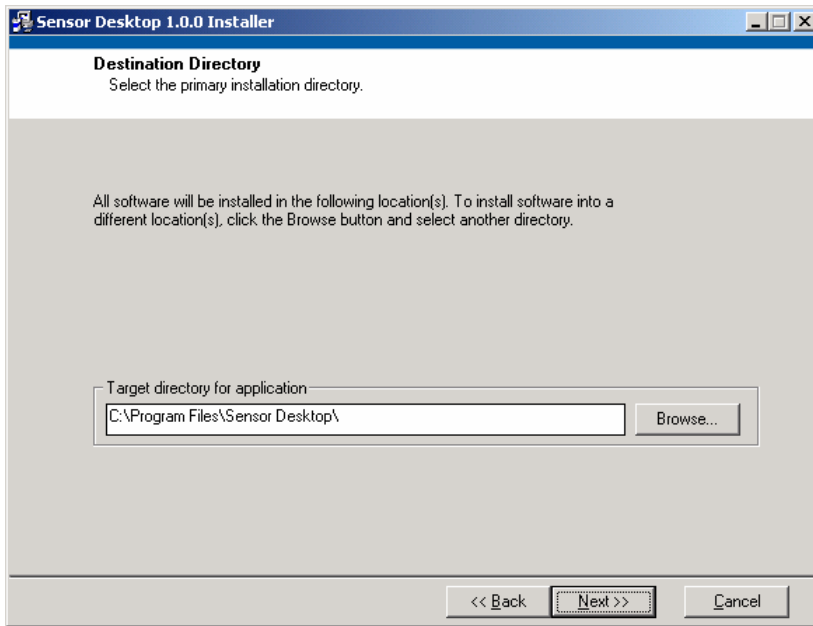
Main components are:

Number	Component
1.	Bluetooth unit
2.	Bosch Sensortec SMB365 acceleration sensor
3.	V <sub>reg</sub> Voltage Regulator and V <sub>Shift</sub> Logic Level Shifter
4.	Microcontroller Programming Interface
5.	8bit Microcontroller
6.	Converter ASIC; Bit Parallel to USB
7.	Bosch Sensortec SMD500 pressure sensor
8.	Data Transmission and Control LED's
9.	USB I/O Port
10.	On/Off switch

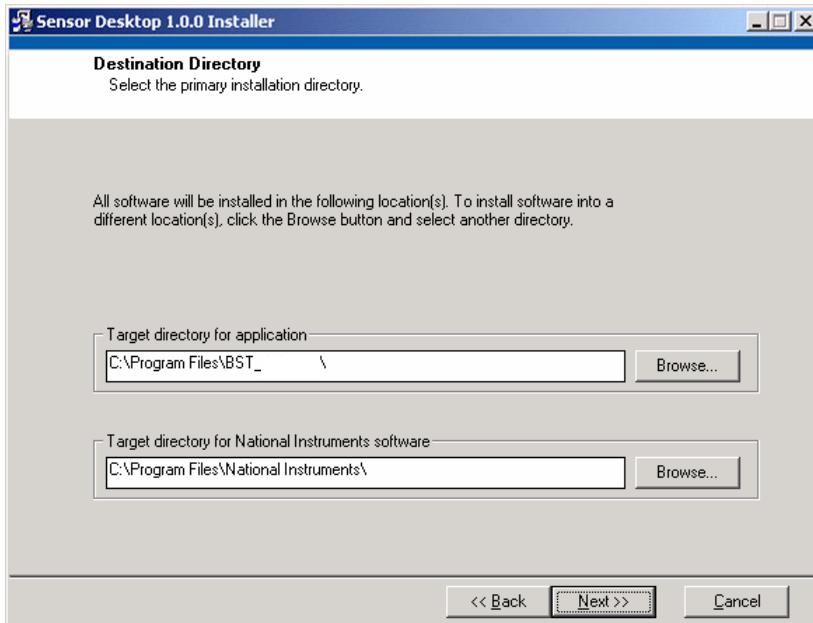


## 2 Hard- & Software Installation

1. Insert SensorDesktop-CD
2. Run “setup.exe” from the directory ...:\ SensorDesktop \_DemoSoftware
3. The following message box appears

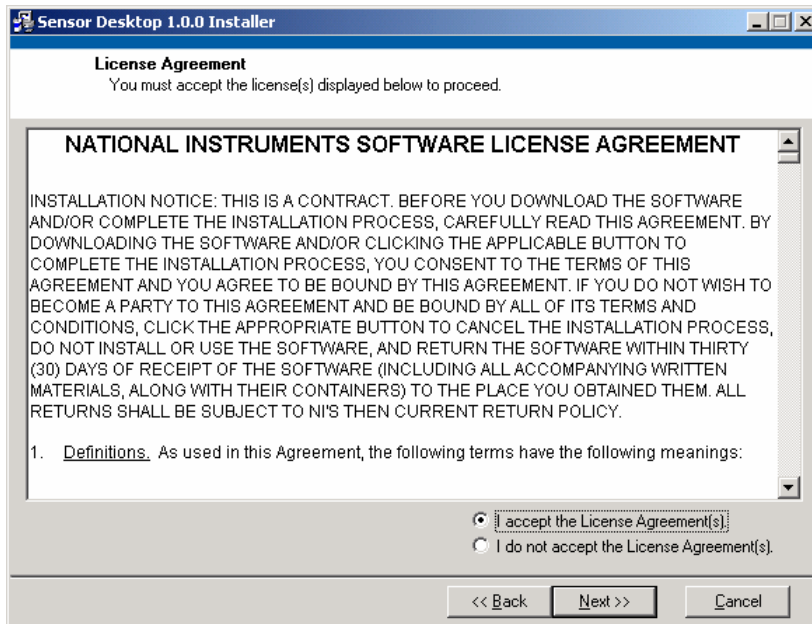


4. Click “Next”
5. The following message box appears



6. Select the primary installation directories “BST\_SensorDesktop” and “National Instruments” in the user specific directory “Program Files” (drive may vary from C:)
7. The following message box appears

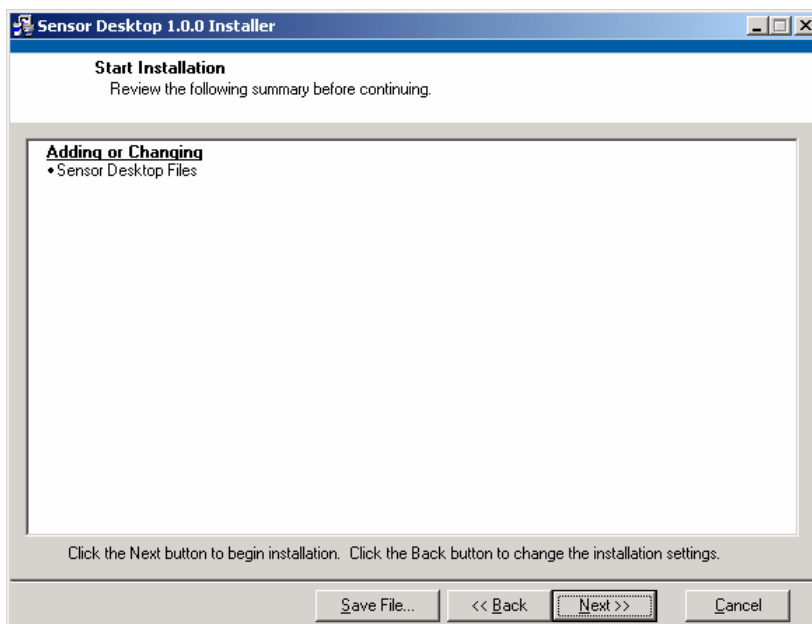




8. Accept the License Agreement(s) as described above.

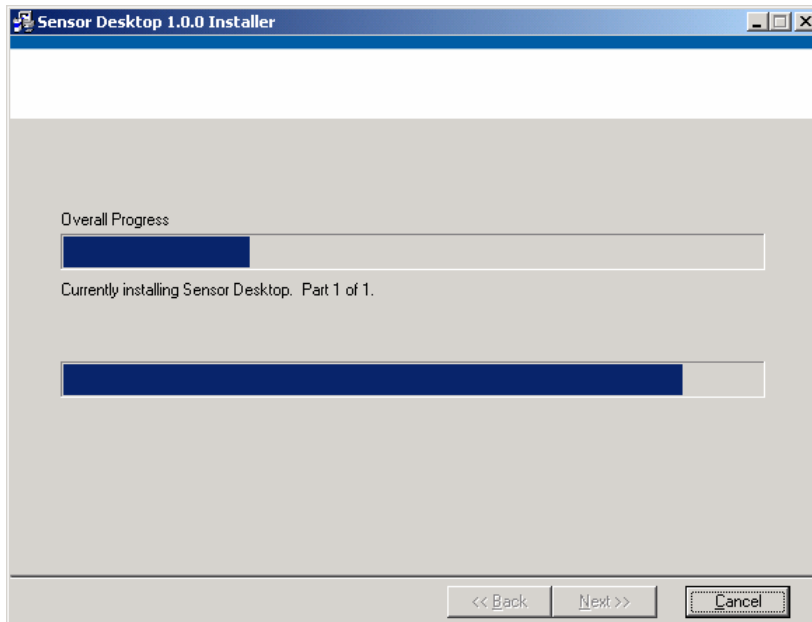
9. Click "Next"

10. The following message box appears



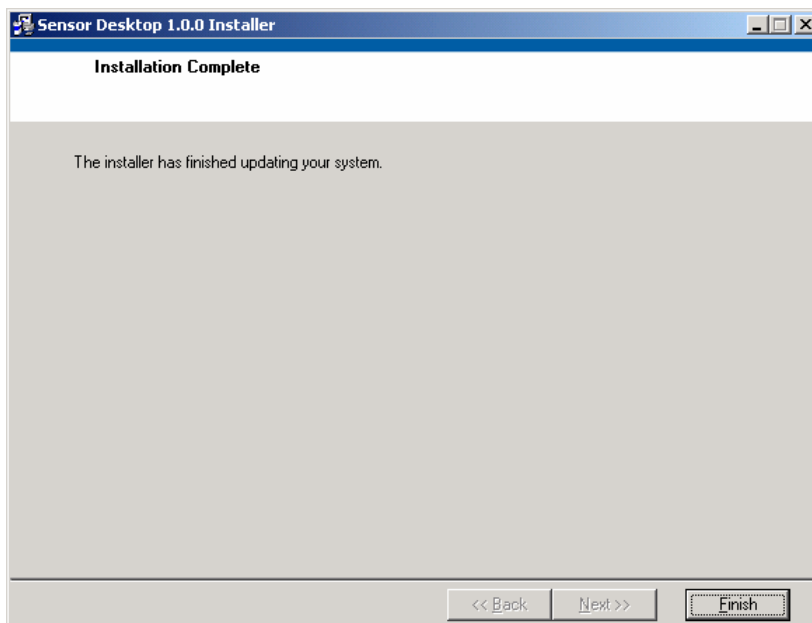
11. Confirm installation by clicking on "Next"

12. While the installation is in progress, the following message box appears



13. Wait until the installation is finished

14. When the installation of SensorDesktop is finished, the following message box appears

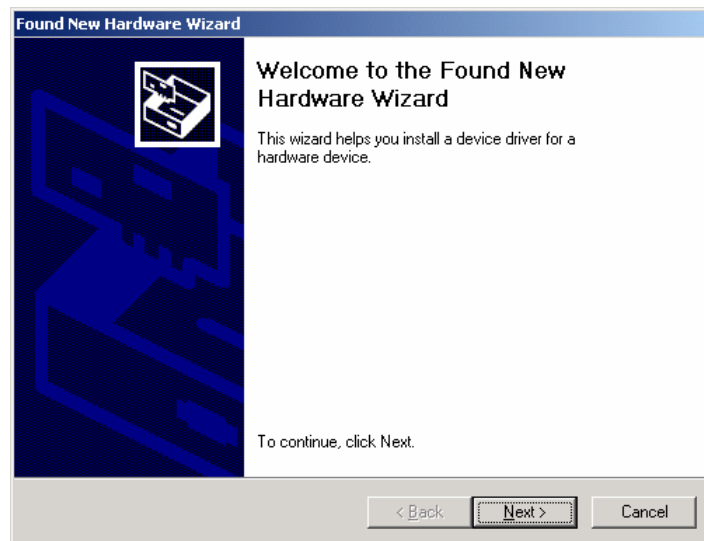
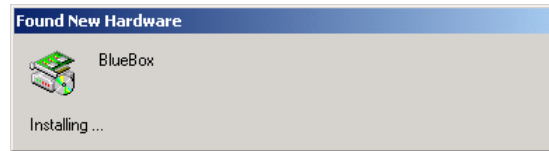


15. Click finish and restart computer if necessary

16. After restarting the computer, connect the BlueBox demo board to a free USB port

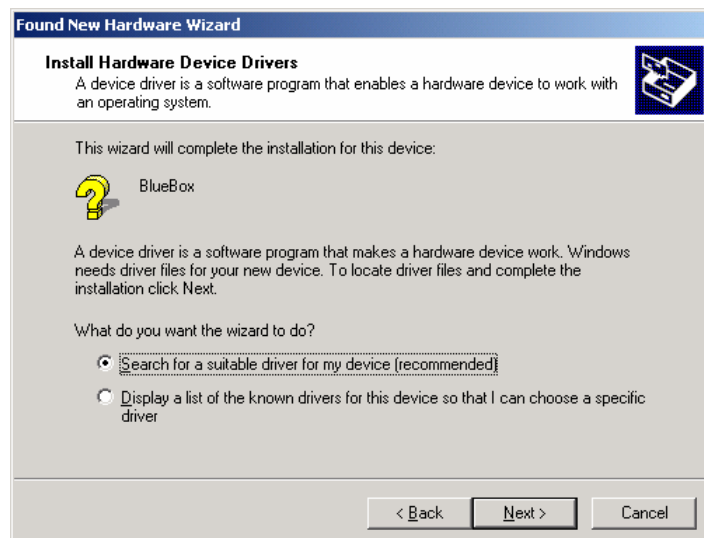
17. Turn on the BlueBox (main switch on the board into the direction to the USB connector)

18. The following message boxes appears



19. Click “Next”

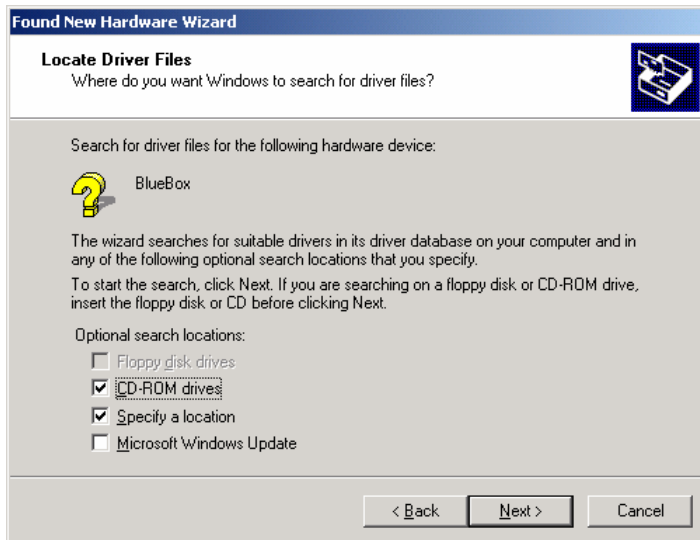
20. The following message box appears



21. Install Hardware Device Drivers by recommended selection as described above

22. Click “Next”

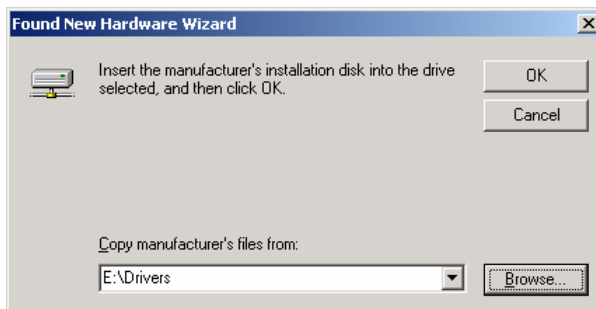
23. The following message box appears



24. Locate Files by selecting “CD-ROM drives” and “Specify a location” as described above

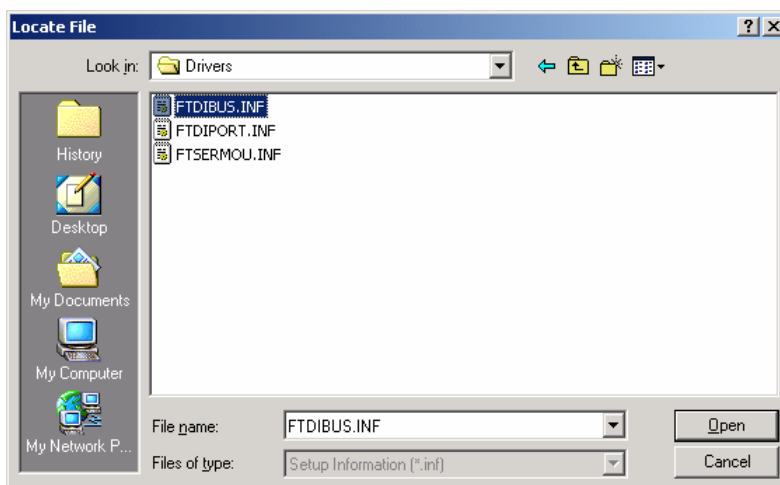
25. Click “Next”

26. The following message box appears



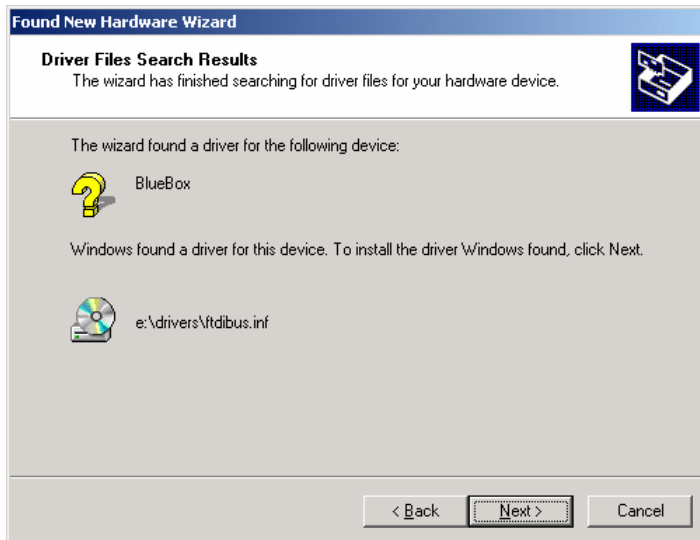
27. Make sure that the correct CD-ROM is inserted and confirm by clicking “OK”

28. Select “FTDIBUS.INF” as Hardware Device Driver



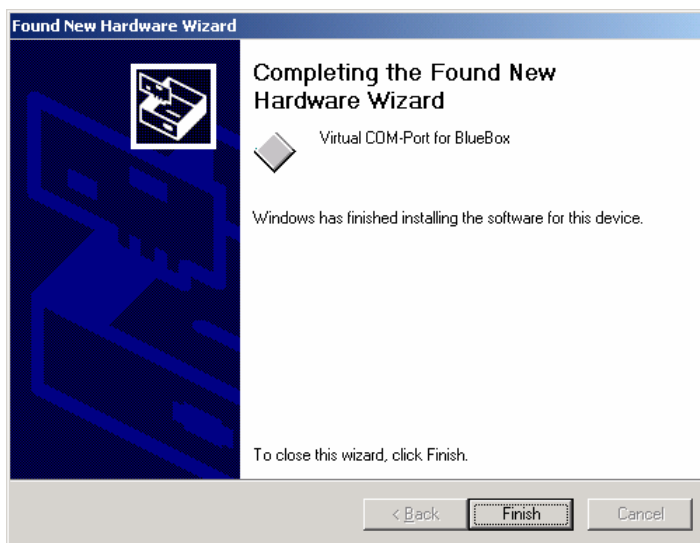
29. Click “Open”

30. If driver file has been successfully found, the following message box appears



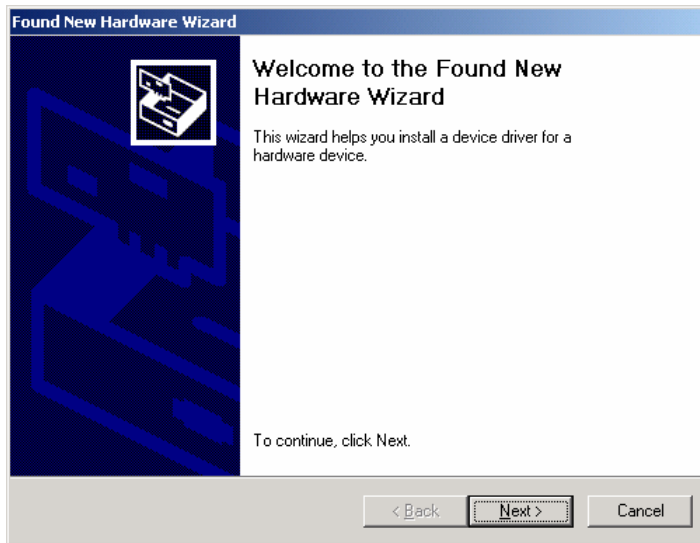
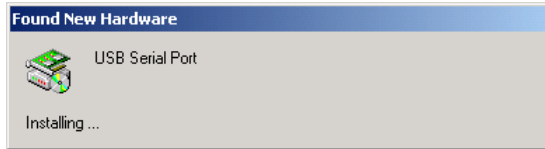
31. Confirm the selection by clicking "Next"

32. If the driver file has been successfully installed, the following message box appears



33. Click "Finish" to complete the FTDIBUS.INF Device Driver installation

34. After finishing of the FTDIBUS.INF Device Driver installation the following message boxes appears



35. Click "Next"

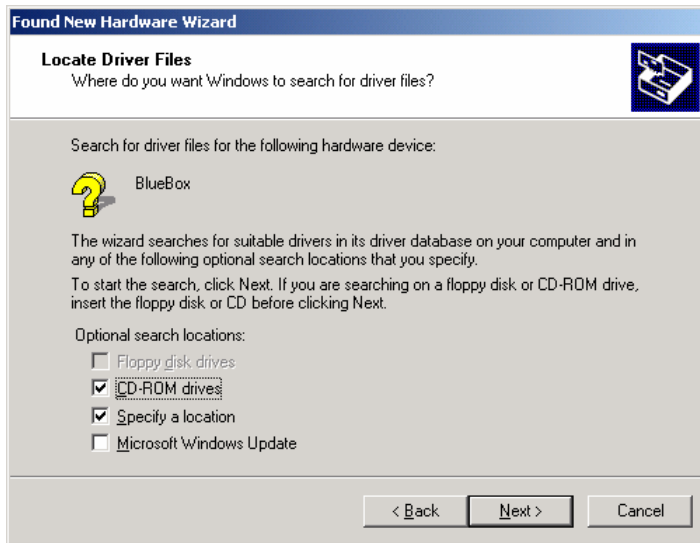
36. The following message box appears



37. Install Hardware Device Drivers by recommended selection as described above

38. Click "Next"

39. The following message box appears



40. Locate Files by selecting “CD-ROM drives” and “Specify a location” as described above

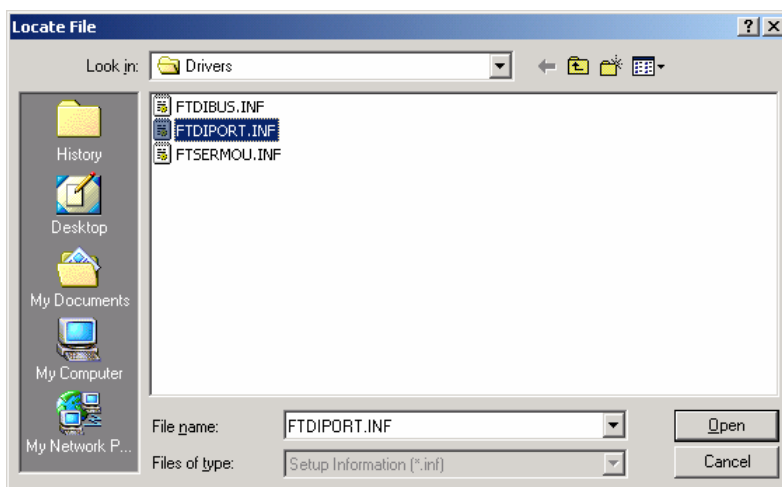
41. Click “Next”

42. The following message box appears



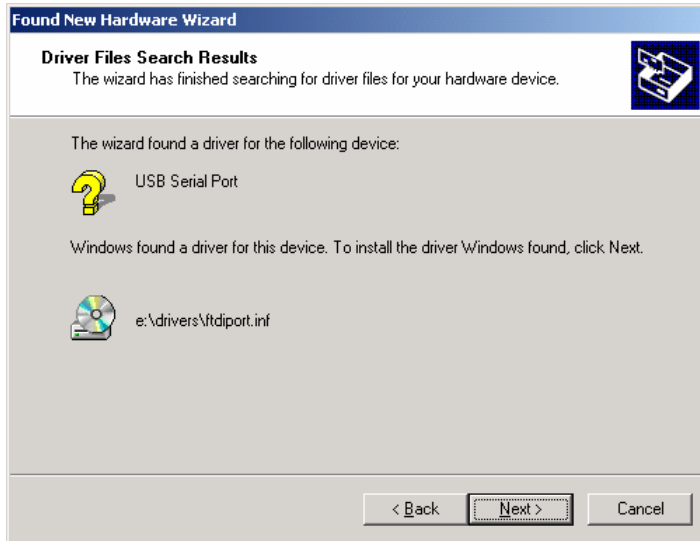
43. Make sure that the correct CD-ROM is inserted and confirm by clicking “OK”

44. Select “FTDIPORT.INF” as Hardware Device Driver



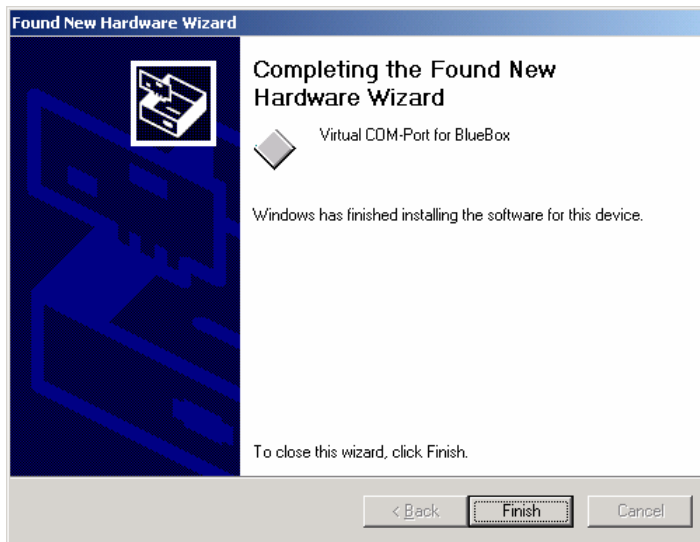
45. Click “Open”

46. If the driver file has been successfully found, the following message box appears



47. Confirm the selection by clicking "Next"

48. If the driver file has been successfully installed, the following message box appears



49. Click "Finish" to complete the Device Driver installation

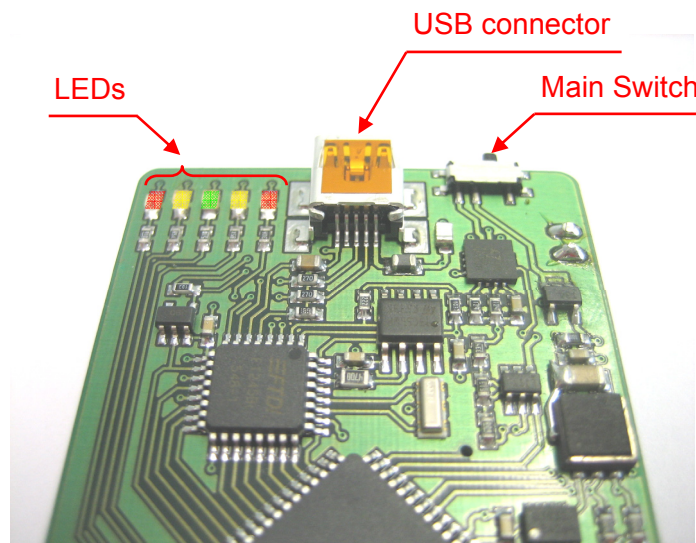


### 3 Quick-Start

*Note: It is strongly recommended that the BST Sensor Desktop software is already installed on your PC before continuing with the following chapters.*

#### 3.1 USB wire bound

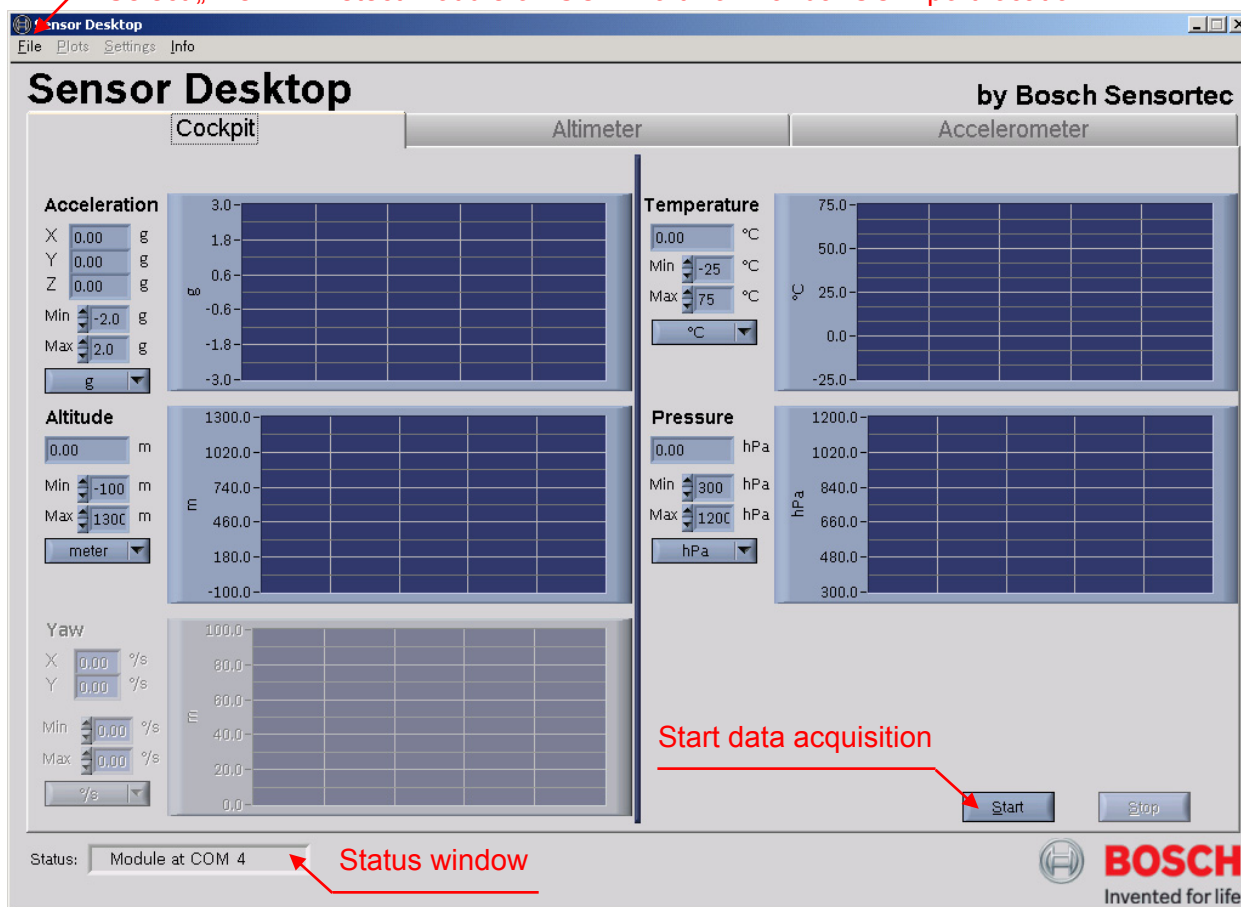
1. Turn on the BlueBox demo board (Main Switch into the direction of the USB connector)
  - The demo board performs a self test indicated as a LED light up sequence
  - LEDs in general from left to right:
    - outer red: (flashes) battery warning
    - yellow: (constant) continuous data transmission
    - green: (constant) logic COM port connection
    - yellow: (alternately flashes with green LED) searching COM port
    - inner red: (constant) recharging battery



2. Connect the BlueBox to a free USB-Port on your PC
  - the red LED on the board indicates: “recharging battery pack”, used for optional wireless operation, the green LED indicates “logic connection to COM port O.K.”
3. Execute the SensorDesktop software on the PC from Start\Programs\ SensorDesktop

4. After starting the software, the cockpit window of the BlueBox software appears. The software tries to locate automatically the corresponding COM port of the demo board. If the demo board is located, a status message at the bottom left hand corner of the software window will indicate to which COM port the module is connected. If the status window indicates “Module not found” the board has to be located manual. Only in this case click on “File” → “Detect Module on COM Port” in the status bar.

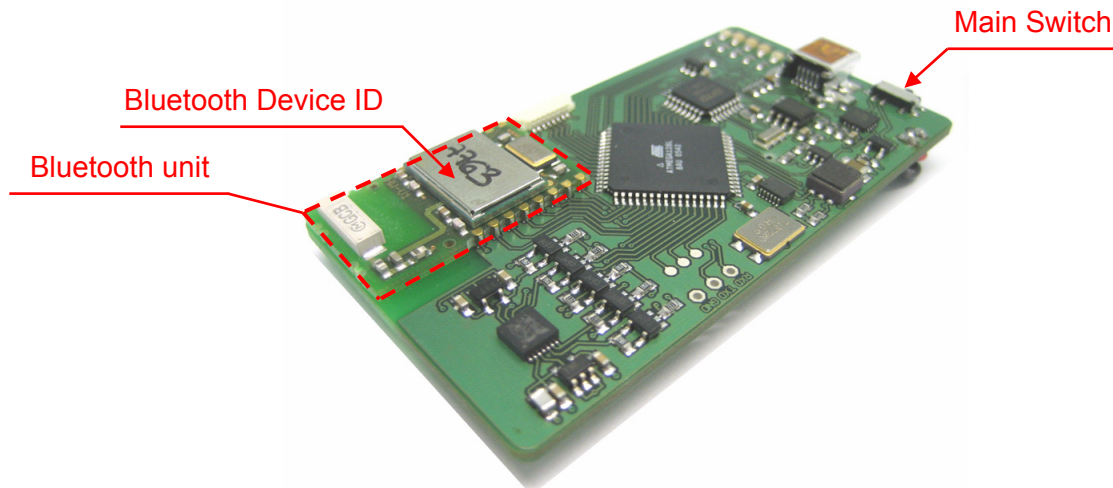
Select „File“ → “Detect Module on COM Port” for manual COM port location




5. Press the „Start“ button to start data acquisition of acceleration and pressure sensor
6. Accelerate, roll, tilt or lift the BlueBox board
7. Watch the graphs in the different displays on the cockpit screen
  - o Note: For exact altimeter response it is strongly recommended to correct the ambient air pressure data before further using the board (see chapter 3.3)

### 3.2 Bluetooth wireless

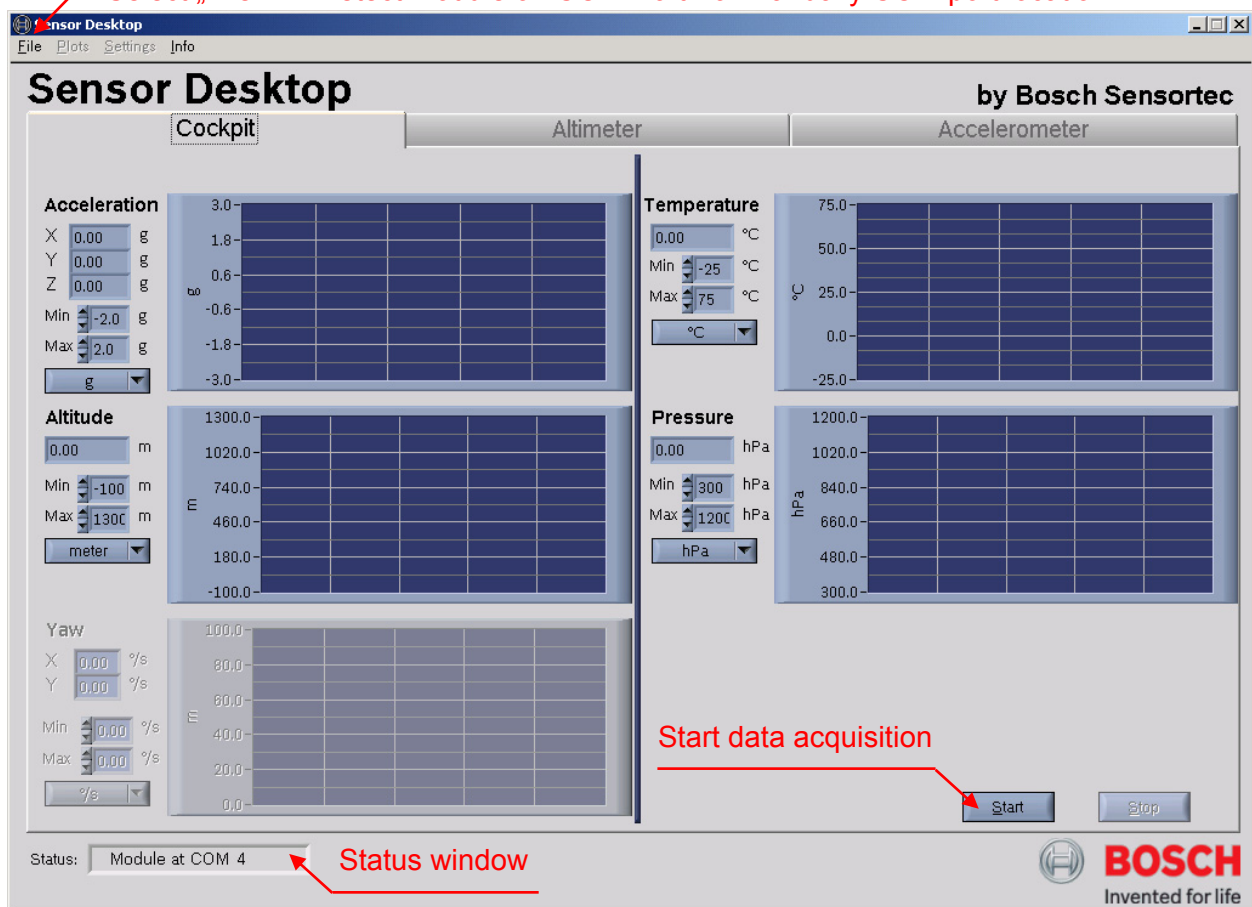
1. Make sure that the used PC or laptop supports Bluetooth capability.
2. Make sure that system specific Bluetooth hard- and software as well as drivers are installed and activated.
3. Before using wireless data transmission via Bluetooth start up the BlueBox once according to chapter 3.1 and let the BlueBox connected at least 5 hours to fully charge the battery pack.




4. Double Click on the Bluetooth symbol  in the system tray or start your Bluetooth software to set up the correct Bluetooth environment for the BlueBoard.
  - o Bluetooth software must support SPP Protocoll (Serial Port Profile) and virtual serial COM port respectively
  - o Configure according to “Pair Devices” or “Pairing”
5. Turn on the BlueBox demo board (USB cable disconnected) for wireless use
6. Search for the corresponding Bluetooth Device ID in Bluetooth environment in this example “7763” according to the illustration above
  - o When asked for Bluetooth Pin or Key enter “0000”
8. Execute the SensorDesktop software on the PC from Start\Programs\ SensorDesktop

9. After starting the software, the cockpit window of the BlueBox software appears. The software tries to locate automatically the corresponding virtual COM port of the demo board. If the demo board is located, a status message at the bottom left hand corner of the software window will indicate, to which COM port the module is connected. If the status window indicates “Module not found” the board has to be located manually. Only in this case click on “File” → “Detect Module on COM Port” in the status bar.

Select „File“ → “Detect Module on COM Port” for manually COM port location



10. Press the „Start“ button to start data acquisition of acceleration and pressure sensor
11. Accelerate, roll, tilt or lift the BlueBox board
12. Watch the graphs in the different displays on the cockpit screen
  - o Note: For exact altimeter response it is strongly recommended to correct the ambient air pressure data before further using the board (see chapter 3.3)

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### 3.3 Custom calibration of the SMD500 altimeter function

With the SMD500, there is the possibility to precisely measure the ambient air- or atmospheric pressure. According to the international barometric formula it is possible to determine the current altitude out of the measured atmospheric pressure. Before using the SMD500 on the BlueBox multi sensor demo board for exact altitude measurements, some facts are good to know:

The ambient air- or atmospheric pressure is a typical weather and temperature related phenomena. As a law of nature, the atmospheric pressure varies in a certain range over the day and can be referred in two ways. Either to the ambient (as is) pressure, including the actual position altitude or to the pressure at sea level (virtual), excluding the altitude of the actual position. This “virtual” or “re-calculated” pressure, the so called pressure at sea level, always refers to the height of “zero” above sea level. According to the international barometric formula mentioned above, altitude (h) in meter, atmospheric pressure (p) and pressure at sea level (p<sub>0</sub>) can be related as followed:

$$h = 44262.7 \cdot \left( 1 - \left( \frac{p}{p_0} \right)^{\frac{1}{5.255}} \right) \quad h \text{ in meter}$$

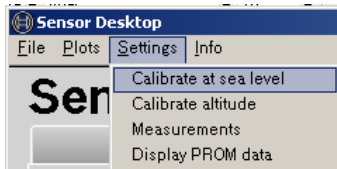
According to the formula above, the SMD500 always measures precisely the absolute atmospheric pressure, including height, temperature and weather effects. In combination with the pressure at sea level, it is possible e.g. to determine the altitude. For accurate altitude measurements, using the SMD500 on the BlueBox demo board, it is necessary to recalibrate the board at least once a day. For an exact altitude measurement we recommend to calibrate the board straight before the measurement.

Generally, there are three possibilities for a calibration. On the one hand, if the exact sea level pressure is known or possible to get (e.g. from internet or a nearby airport), there is the possibility to “calibrate at sea level” either “via internet” or “manual”. On the other hand, if the exact altitude is known, there is the possibility for a calibration using the function “calibrate altitude”.

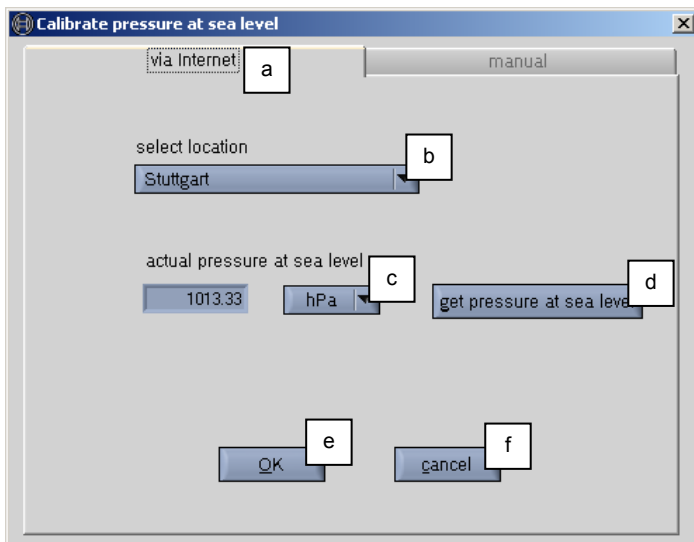
### 3.3.1 Calibrate at sea level via internet

This function applies to altitude measurements under a known sea level pressure obtained from the internet.

1. Open Settings → Calibrate at sea level



2. Chose “via internet tab” [a]

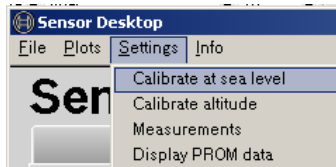


3. Connect the PC to the internet
4. Select the nearby location from the default list [b]
  - location in default list should be < 200 km off current location
  - if current location is > 200 km in distance calibrate according chapter 3.3.2
5. Choose the unit [c]
6. Press “get pressure at sea level” [d] for pressure at sea level update
7. Confirm with OK [e] or cancel [f] selection

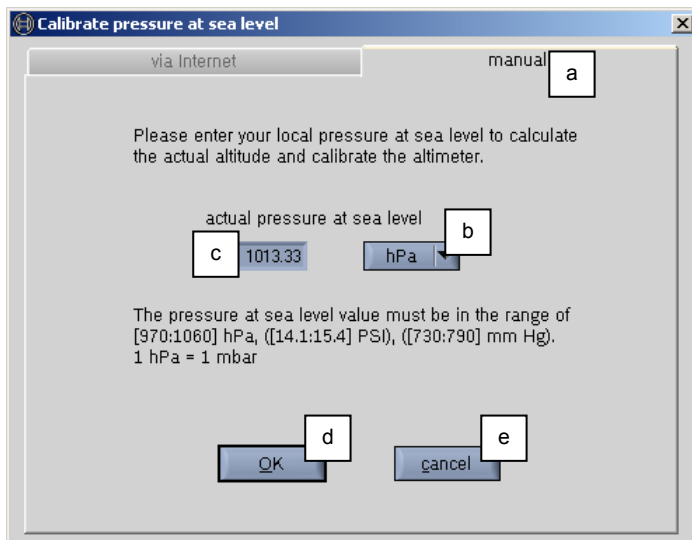
### 3.3.2 Calibrate at sea level manually

This function applies to altitude measurements under a known and manually obtained sea level pressure.

1. Open Settings → Calibrate at sea level



2. Choose “manual tab” [a]

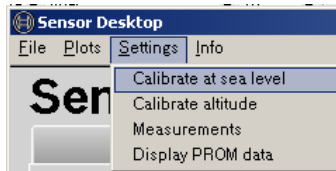


3. Obtain current pressure at sea level
  - E.g. from local weather service or nearby airport
4. Choose corresponding unit [b]
5. Put in the pressure value [c]
6. Confirm with OK [d] or cancel [e] selection

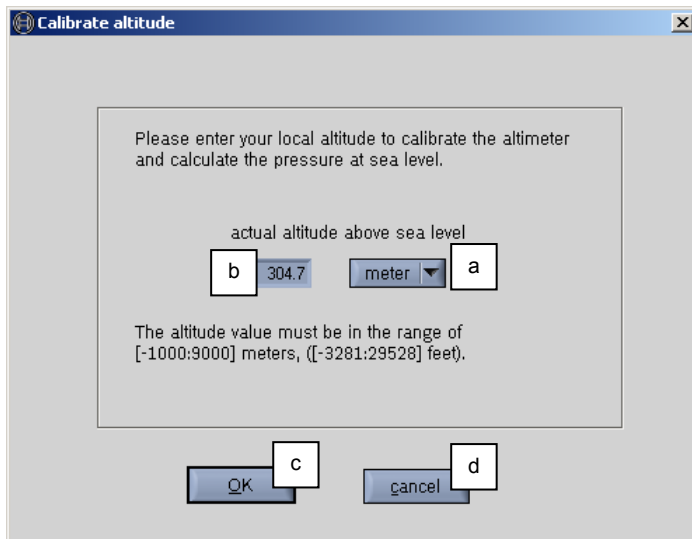
### 3.3.3 Calibrate altitude manually

This function applies to pressure measurements under a known and manually obtained altitude

1. Open Settings → Calibrate altitude



2. the following message box appears



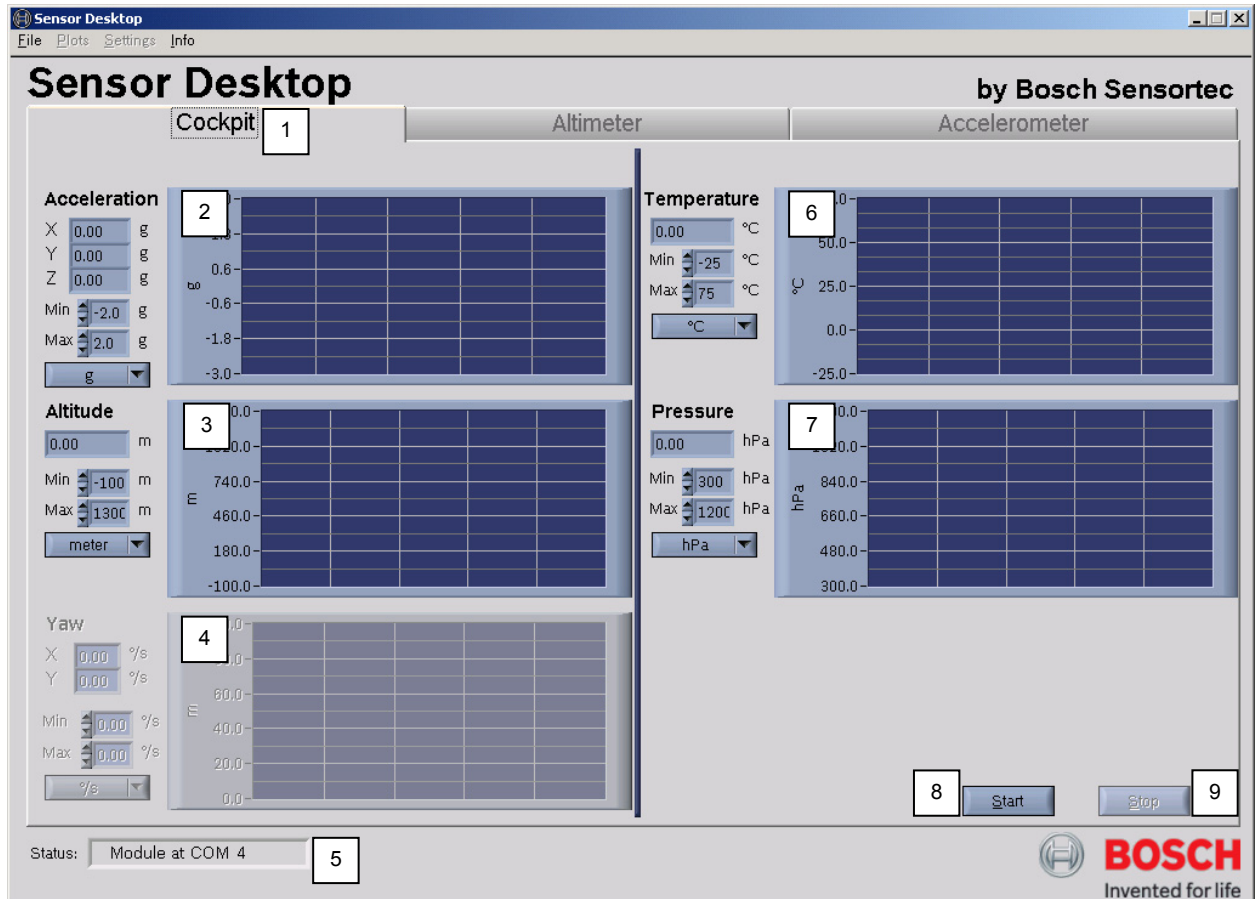
3. Obtain actual altitude above sea level
  - o E.g. from map with altitude details, travel guide or internet
4. Choose corresponding unit [a]
5. Put in the altitude value [b]
6. Confirm with OK [c] or cancel [c] selection



## 4 Operation

### 4.1 The BlueBox Cockpit Window


The following figure gives an overview of the BlueBox Cockpit Window



#### 1. Cockpit Tab

#### 2. Acceleration display (SMB365)

- Display shows output signals of all 3 axes (X, Y, Z) of the SMB365 in g
- 1 g corresponds to an acceleration of approximately 9,81 m/s<sup>2</sup>
- The abscissa (x-coordinate) corresponds to time in seconds
- The ordinate (y-coordinate) corresponds to acceleration in g
- The ordinate features custom Min/Max scaling ( $\pm 2g$  full scale in low g mode)

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### 3. Altitude Display (SMD500)

- The display shows the primary output signal of the SMD500 converted to altitude
- 8.5 m differential height corresponds to an differential pressure of about 1 hPa pressure at sea level
- The abscissa (x-coordinate) corresponds to time in seconds
- The ordinate (y-coordinate) corresponds to altitude in meter or feet
- The ordinate features custom min/max scaling

### 4. Yaw Display (SMG300)

- Disabled on BlueBord V1.0

### 5. COM Port Status Window

- Indicates connection status of the BlueBoard demo board

### 6. Temperature Display (SMD500)

- Display shows temperature as a secondary output signal of the SMD500 in °C, °F or K (details see chapter 4.2 [18] )
- The abscissa (x-coordinate) corresponds to time in seconds
- The ordinate (y-coordinate) corresponds to the temperature in °C, °F or K
- The ordinate features custom min/max scaling

### 7. Pressure Display (SMD500)

- Display shows the primary output signal of the SMD500 in hPa, PSI or mm Hg
- 1hPa is equal to a pressure of 1mbar
- The abscissa (x-coordinate) corresponds to time in seconds
- The ordinate (y-coordinate) corresponds to absolute pressure in hPa, PSI or mm Hg
- The ordinate features custom min/max scaling

### 8. Start button

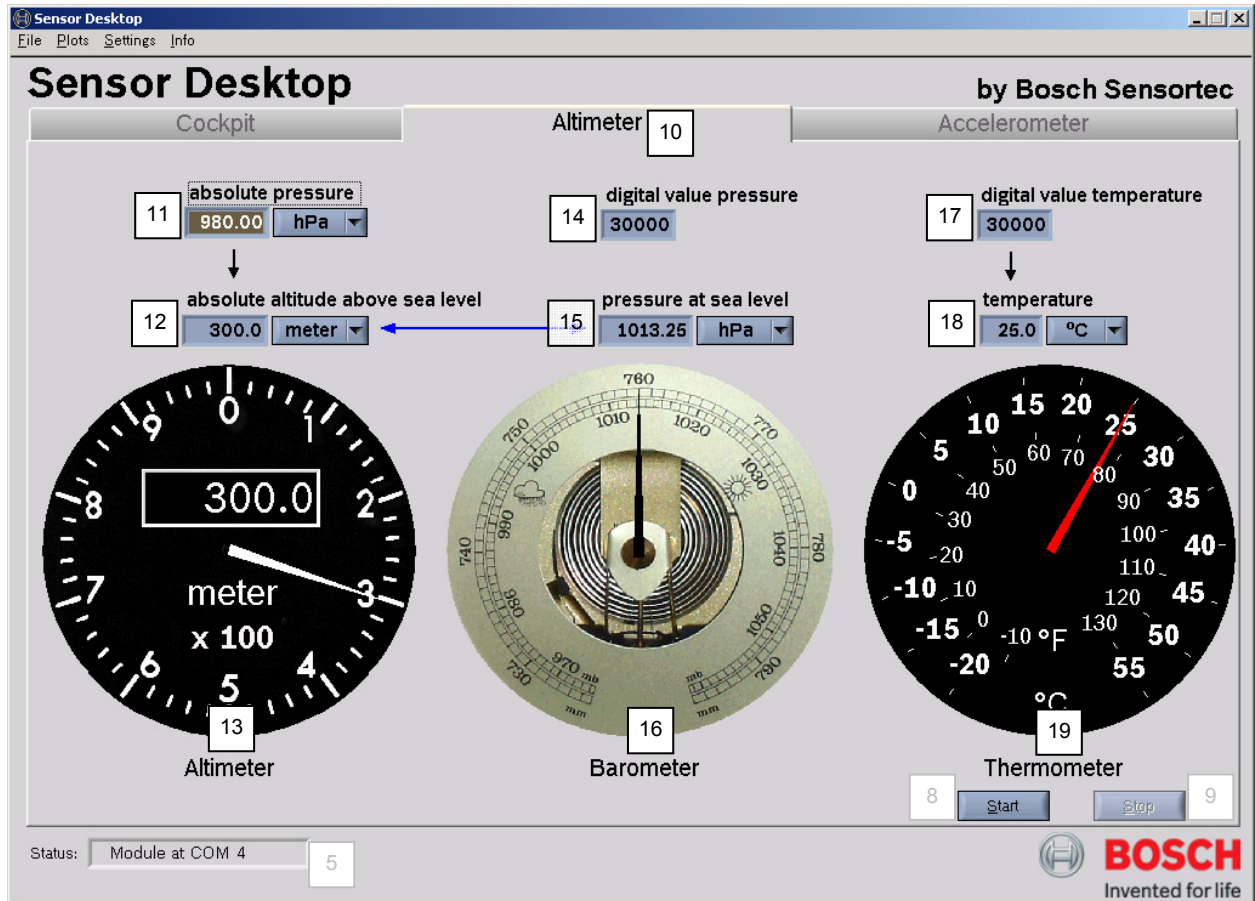
- To start data acquisition of acceleration- and pressure sensor output signals

### 9. Stop button

- To end data acquisition of acceleration- and pressure sensor output signals

**4.2 The BlueBox Altimeter Window**

The following figure gives an overview of the BlueBox Altimeter Window



**10. Altimeter Tab**

**11. absolute pressure**

- Display shows the absolute pressure in hPa, PSI or mm Hg
- hPa, PSI and mm Hg can be converted as followed:
  - $PSI = hPa * 0.01450377$
  - $mm\ Hg = hPa / 1.333224$
  - $hPa = PSI / 0.01450377$
  - $mm\ Hg = PSI * 51.71496$
  - $hPa = PSI / 0.01450377$
  - $mm\ Hg = hPa * 1.333224$

**12. absolute altitude above sea level**

- Display shows the absolute altitude above sea level in meter or feet
- the absolute altitude in meter is calculated according to the international barometric formula (see chapter 3.3)
- meter and feet can be converted as followed:
  - $\text{meter} = \text{feet} / 0.3048$
  - $\text{feet} = \text{meter} * 0.3048$

**13. Altimeter gauge**

- Display shows the calculated altitude in the meter or feet

**14. digital value pressure**

- Display shows digital output pressure value of the SMD500 in LSB

**15. pressure at sea level**

- Display shows the pressure at sea level in hPa, PSI or mm Hg

**16. Barometer gauge**

- Display shows the pressure at sea level in hPa, PSI and mm Hg

**17. digital value temperature**

- Display shows digital output temperature value of the SMD500 in LSB

**18. Temperature**

- Display shows the calculated temperature value in °C, °F or K
- Fahrenheit, Kelvin and Celsius can be converted as followed:
  - $^{\circ}\text{F} = ^{\circ}\text{C} * 1.8 + 32$
  - $\text{K} = ^{\circ}\text{C} + 273.15$
  - $^{\circ}\text{C} = (^{\circ}\text{F} - 32) / 1,8$
  - $\text{K} = ^{\circ}\text{F} + 459.67 / 1.8$
  - $^{\circ}\text{C} = \text{K} - 273.15$
  - $^{\circ}\text{F} = \text{K} * 1.8 - 459.67$

**19. Thermometer gauge**

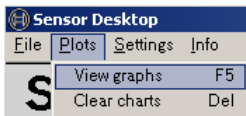
- Display shows the calculated temperature value in °C and °F

## 4.2.1 Additional Plots and Altimeter Settings

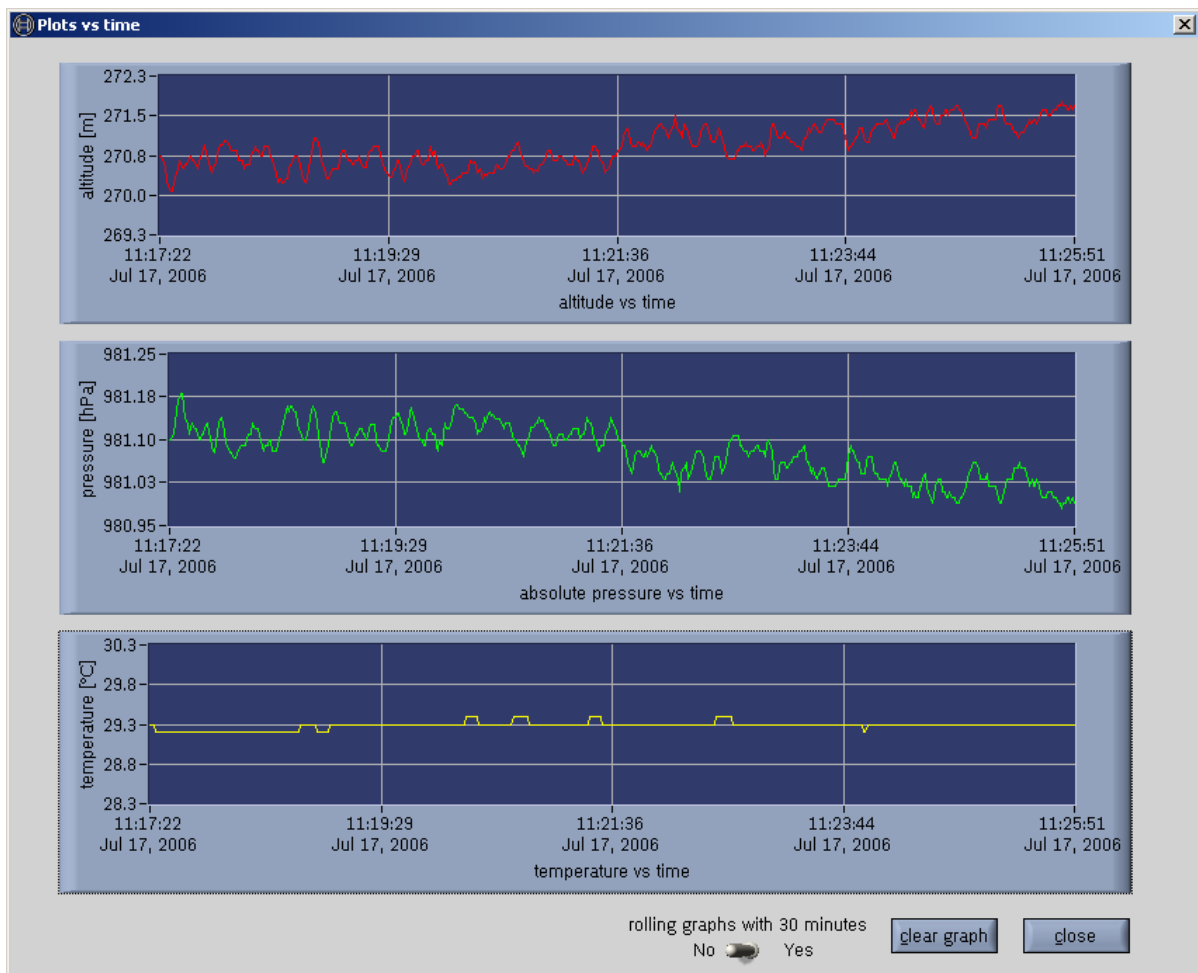
### Plots


For a more detailed view of the SMD500 related signal outputs there is the possibility to express the data (altitude, pressure, temperature) in additional plots as followed:

1. Open plots → View graphs



2. The following plot box appears



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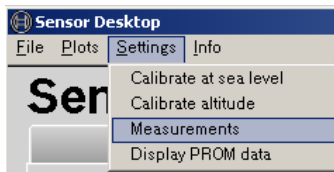
### 3. Edit or customize plot box view

- Three plots will be generated
  - Altitude, Pressure and Temperature
- All three plots offer automatically scaling of the y-axis
- In general there are 2 views possible
  - Rolling graphs with 30 minutes (Yes or No)
  - Rolling only effects data of > 30 min sampling time
  - The two views are not reversible, if changed after 30 minutes
- Rolling graphs with 30 minutes: YES
  - After 30 minutes the measurement starting point will be scrolled
  - There will be only the last 30 minutes of measurement data visible
- Rolling graphs with 30 minutes: NO
  - After 30 minutes the time scale will be scaled
  - All measurement data will be visible according to the new time scale

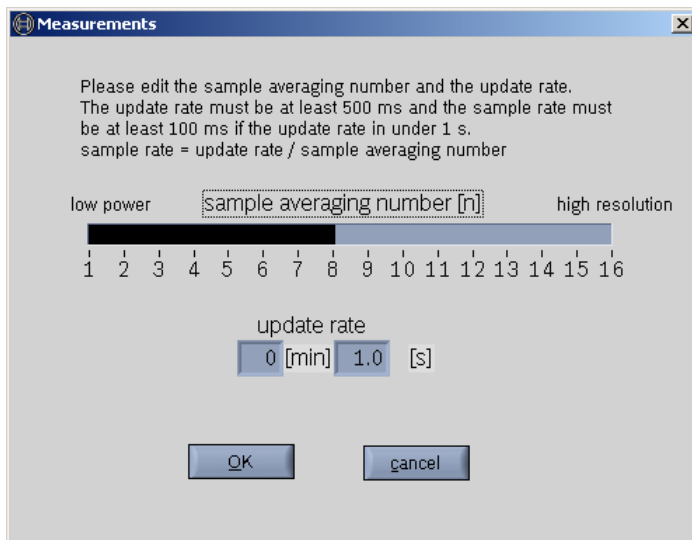
**Settings → Measurements**

According to customized settings (high signal resolution or low power consumption) it is possible to choose different sample averaging numbers and update rates. E.g. increasing the resolution leads to a decreased noise with increased power consumption and contrariwise. This behavior can be edited by the following:

4. Open Settings → Measurements



5. The following message box appears



6. Chose sampling average number and update rate according to the text
  - sampling average number = Number of single values for avg. calculation
    - edit by mouse scroll
  - update rate = time for a new “send data command”
    - Minimum update rate 0.5 s
  - sample rate = update rate / sampling average number
    - Minimum sampling rate 0.1 s
    - Maximum 2 values per second (2 Hz) possible

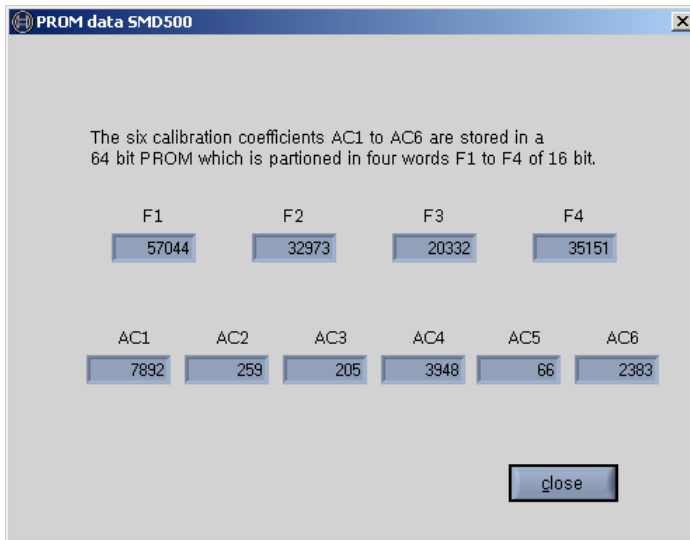
## Settings → Display PROM Data

For some basic evaluation purposes, there is the possibility to display the stored SMD500 PROM data.

1. Open Settings → Display PROM data



2. The following message box appears

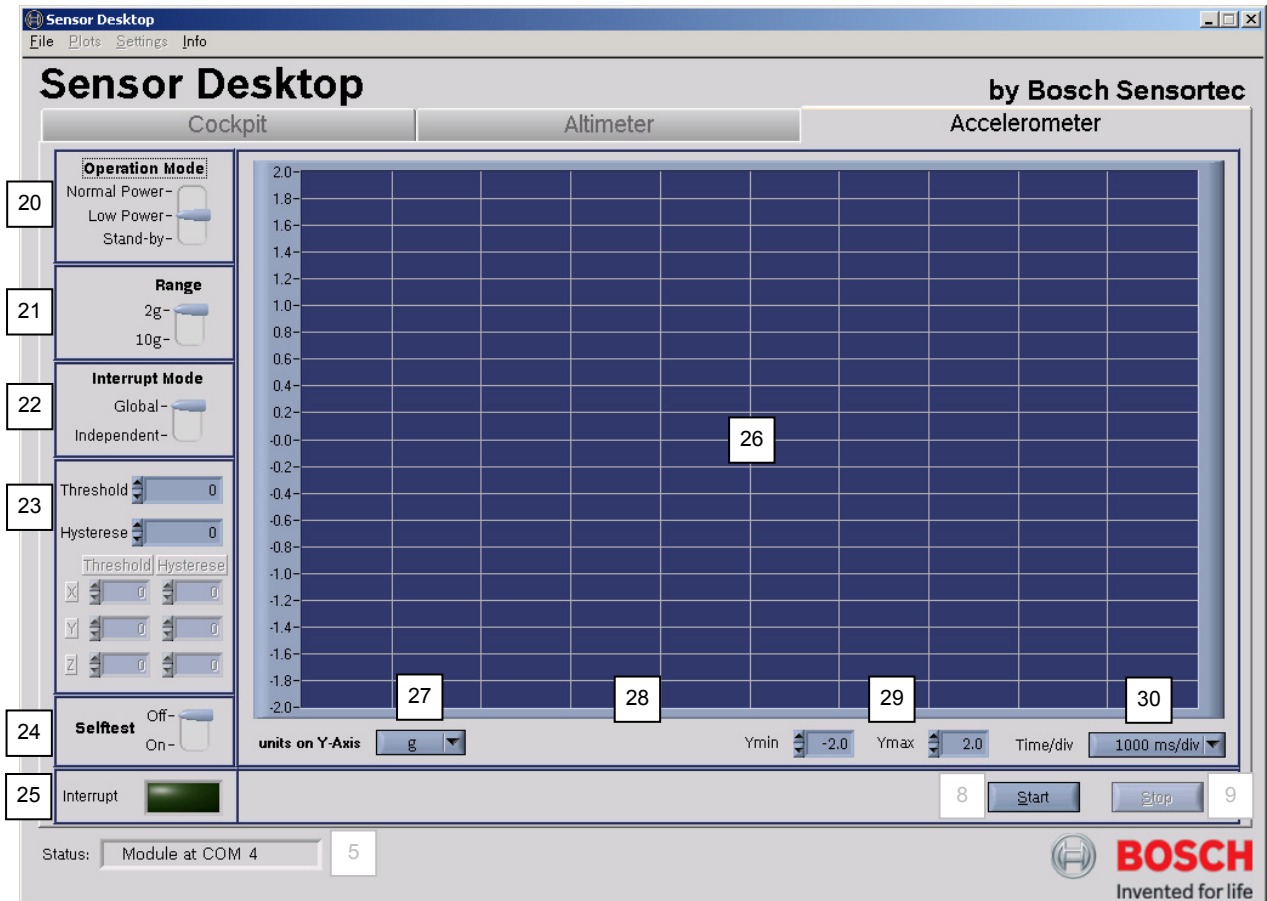


3. It is possible to manually view the stored data:
  - AC1 to AC6 are the calibration coefficients expressed as raw data
    - varying from 9 to 14 bit words
  - F1 to F4 are shifted calibration coefficients
    - shifted to generate 4 uniform 16 bit words containing the 6 AC coefficients



### 4.3 The BlueBox Accelerometer Window

The following figure gives an overview of the BlueBox Accelerometer Window



#### 20. Sensor Mode selection


- Normal Power for full performance mode (10bit resolution)
- Low Power for interrupt mode (7bit resolution)
- Standby for energy saving mode (0bit resolution)

#### 21. Acceleration range selection

- $\pm 2g$  for low g applications
- $\pm 10g$  for high g applications

#### 22. Interrupt mode selection

- global interrupt conditions (same for all axes)
- independent interrupt conditions (individual for each axis)

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### 23. Hysteresis and Threshold level settings

- for global interrupt conditions
  - Threshold and Hysteresis for all axes are given in digits (d) of a 7bit word
  - 1d corresponds to 4 LSB (16mg in low g mode and 0.08g in high g mode)
- for axis individual interrupt conditions
  - Threshold for each axis is given in digits (d) of a 5bit word
  - 1d corresponds to 16 LSB (64mg in low g mode and 0.32g in high g mode)
  - Hysteresis for each axis is given in digits (d) of a 3 bit word
  - 1d corresponds to 64 LSB (256mg in low g mode and 1.28g in high g mode)

### 24. Selftest selection

- Off/On (disable/enable) selftest to check signal evaluation path (MEMS plus ASIC)

### 25. Interrupt signal output LED

- LED off = interrupt inactive; LED on = interrupt active
- No software-function but direct readout of the SMB365 internal interrupt logic pin

### 26. Acceleration signal output screen

- Acceleration sensitive digital signal, given in LSB, g or m/sec<sup>2</sup>
- 1LSB corresponds to 4mg in low g mode and 20mg in high g mode

### 27. Ordinate unit selection (acceleration)

- choose proper unit of acceleration sensor output signal (g, m/s<sup>2</sup> or LSB)

### 28. Output signal reference color

- X-axis = green      Y-axis = yellow      Z-Axis = red

### 29. Ordinate scale selection (acceleration)

- full scale:  $\pm 512\text{LSB}$ ,  $\pm 20\text{m/s}^2$  or  $\pm 2\text{g}$  in 2 g range (resolution: 1LSB = 4mg)
- full scale:  $\pm 512\text{LSB}$ ,  $\pm 100\text{m/s}^2$  or  $\pm 10\text{g}$  in 10g range (resolution: 1LSB = 20mg)

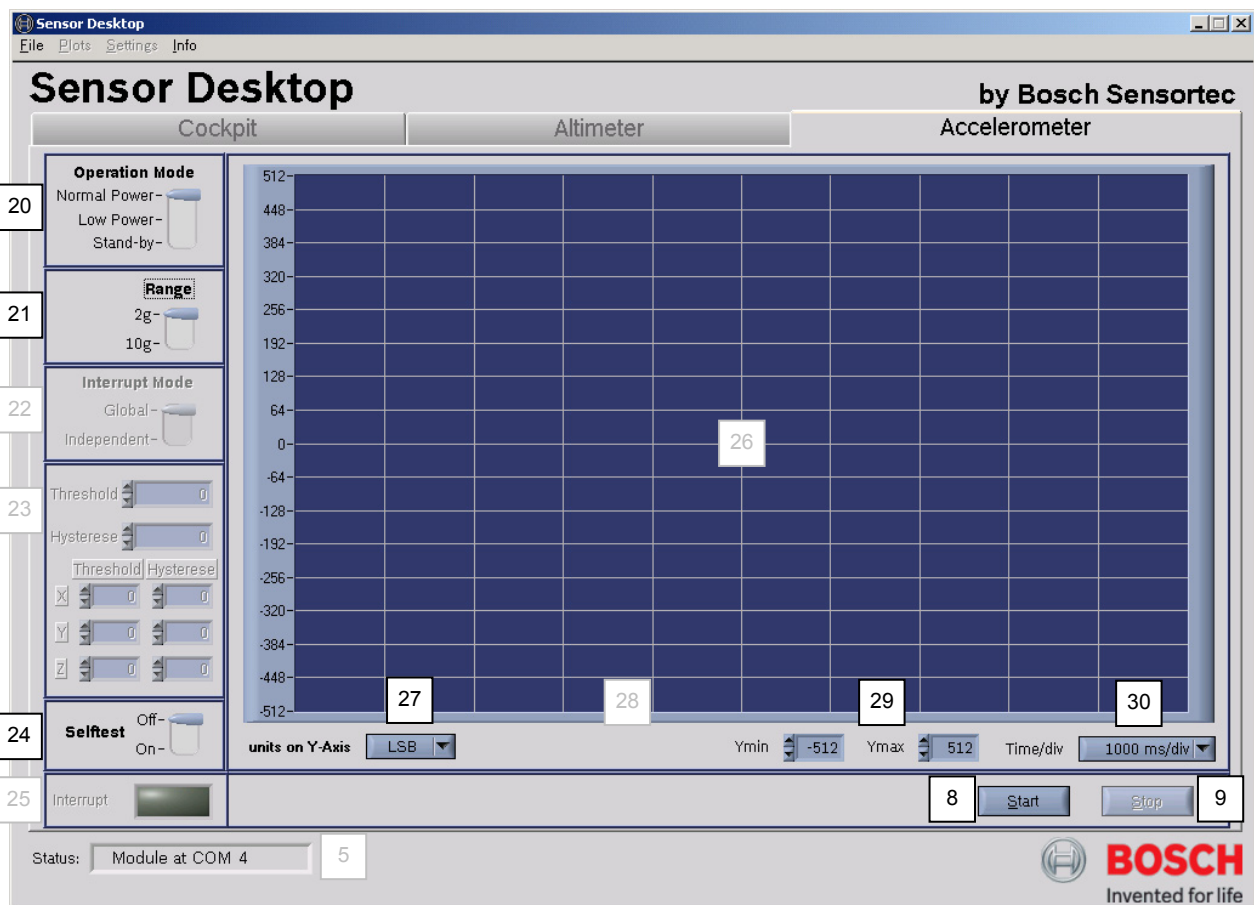
### 30. Abscissa scale selection (timebase)

- select from 2000 to 50 msec/div

### 4.3.1 SMB365 Normal-Power Mode

Software and sensor offer the following features

- Full performance (10bit resolution)
- Two selectable acceleration ranges: 2g and 10g
- Full selftest capability (see chapter 4.3.4)
- No interrupt functionality



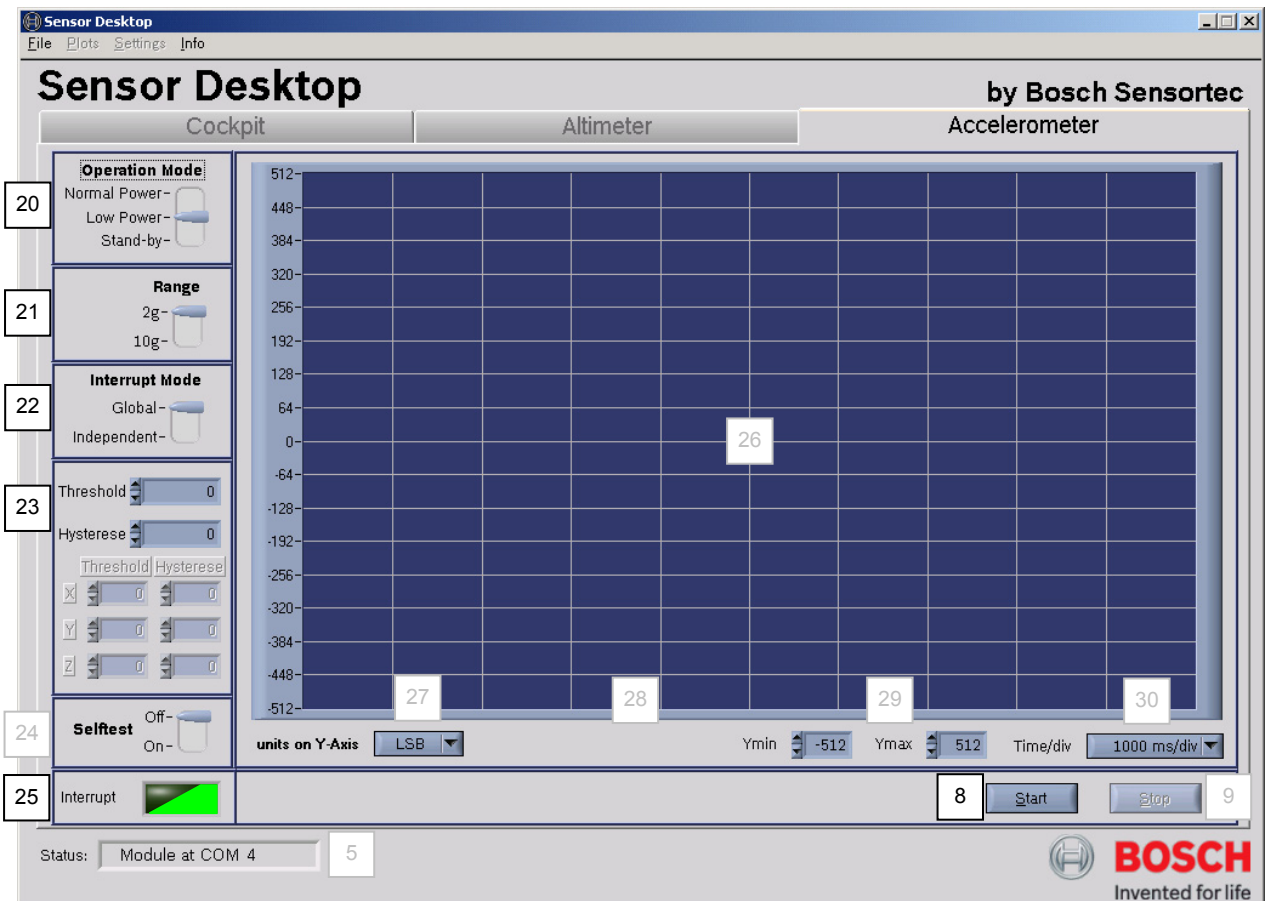
How to set up the SMB365 in Normal-Power mode:

- Select Normal-Power Mode [20]
- Select any acceleration range [21]
- Scale ordinate [27], [29] and abscissa [30]
- Start and stop data acquisition [8], [9] or activate self test [24] during data acquisition


**4.3.2 SMB365 Low-Power Mode in global interrupt conditions**

Software and sensor offer the following features

- Interrupt functionality, e.g. for free-fall demonstration
- Increased acceleration output signal speed
- Reduced power consumption (20%)
- Reduced acceleration output signal resolution (7bit)
- Two selectable acceleration ranges: 2g and 10g
- Two selectable acceleration ranges: 2g and 10g
- Individual settings for global interrupt:
  - Threshold (7bit): 1d = 4LSB (16mg in 2g mode and 0.08g in 10g mode)
  - Hysteresis (7bit): 1d = 4LSB (16mg in 2g mode and 0.08g in 10g mode)
- Full selftest capability (see chapter 4.3.4)



How to set up the SMB365 in global interrupt conditions:

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- Select Low-Power Mode [20]
- Select any acceleration range [21]
- Select Global Interrupt Mode [22]
- Put in global Hysteresis and Threshold digits [23]
- Start data acquisition [8]
- Accelerate, roll or tilt the BlueBox board while watching the interrupt LED [25]

Notes:

The triggering of an interrupt depends, in the first instance, on global Threshold value settings. The global Threshold can be assumed as the interrupt “switch-on” level which must be exceeded from at least one axis dependent acceleration signal. If any acceleration signal exceeds this value, an interrupt will be activated. If all signals are below the Threshold value again, the interrupt will be deactivated, provided that the Hysteresis value is set to zero, e.g.:

$$LED [25] = 1 \text{ if } LSB_x > Threshold \text{ OR } LSB_y > Threshold \text{ OR } LSB_z > Threshold$$

$$LED [25] = 0 \text{ if } LSB_x < Threshold \text{ AND } LSB_y < Threshold \text{ AND } LSB_z < Threshold$$

In addition to the global Threshold value a global Hysteresis value can also be set. The Hysteresis can be assumed as the interrupt “switch-off” level, which must be under-run again from all signals, to deactivate the triggered interrupt. It relates directly to the before set Threshold value by a mathematical subtraction. The following example shows how to set up the global Threshold and Hysteresis values. The calculation corresponds to the 2g operation mode, e.g.:

$$LED [25] = 1 \text{ if } LSB_x > Threshold \text{ OR } LSB_y > Threshold \text{ OR } LSB_z > Threshold$$

$$LED [25] = 0 \text{ if } LSB_x < Hysteresis \text{ AND } LSB_y < Hysteresis \text{ AND } LSB_z < Hysteresis$$

$$\text{Threshold: } 75d = 75 \cdot 4LSB = 300LSB \quad \infty \quad 75 \cdot 16mg = 1.2g$$

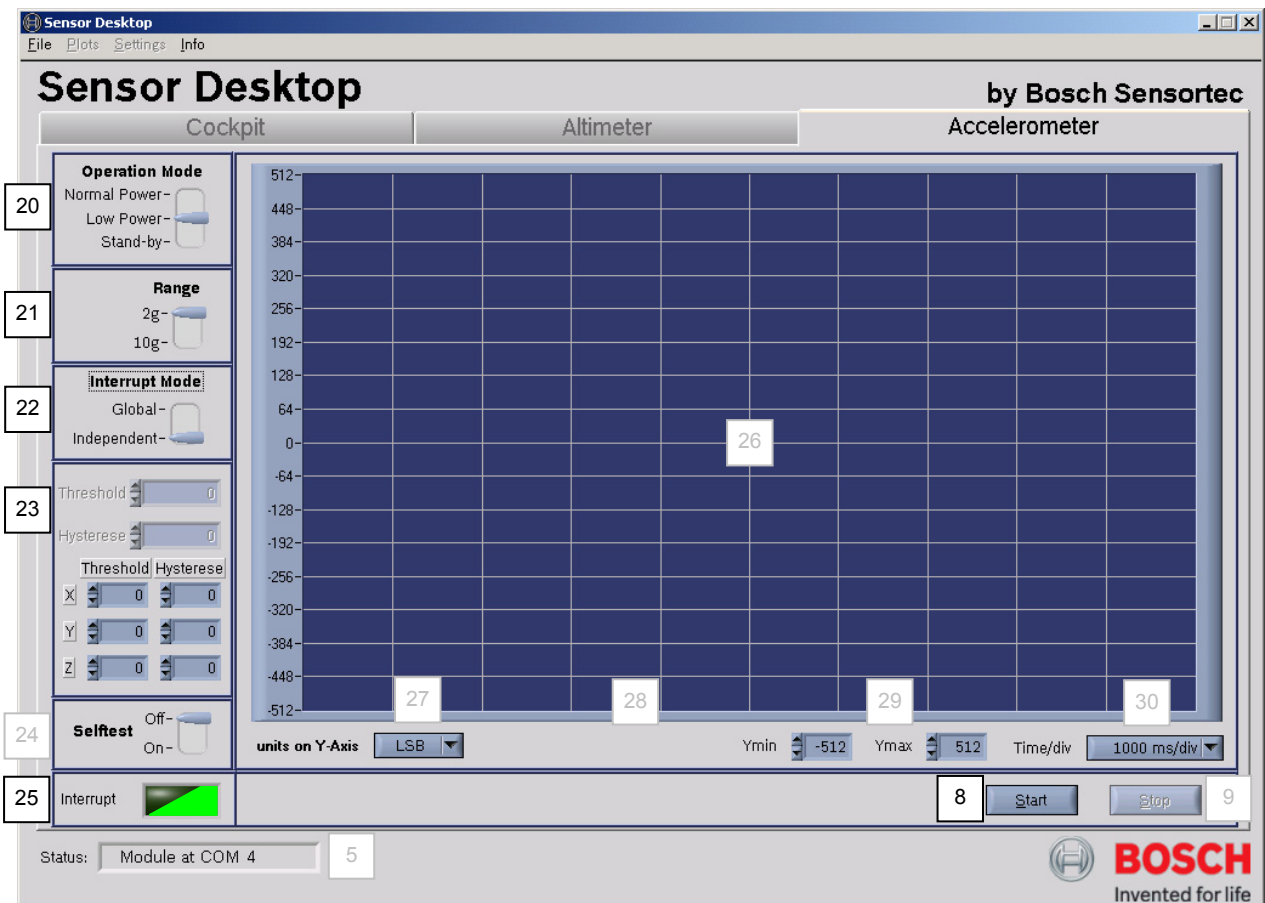
$$\text{Hysteresis: } 25d = 300LSB - 25 \cdot 4LSB = 200LSB \quad \infty \quad 1.2g - 25 \cdot 16mg = 0.8g$$

If Hysteresis is equal or above Threshold, the interrupt functionality will be disabled. For a total reset of the sensor internal interrupt information just switch to standby mode [20] and continue.

#### 4.3.3 SMB365 Low-Power Mode in independent interrupt conditions


Software and sensor offer the following features

- Interrupt functionality, e.g. for theft protection
- Reduced power consumption (20%)
- Reduced acceleration output signal resolution (7 bit)
- Two selectable acceleration ranges: 2g and 10g
- Individual interrupt settings for each axis:
  - Threshold (5 bit): 1d = 16LSB (64mg in 2g mode and 0.32g in 10g mode)
  - Hysteresis (3 bit): 1d = 64LSB (256mg in 2g mode and 1.28g in 10g mode)
- Full selftest capability (see chapter 4.3.4)



How to set up the SMB365 in axis independent interrupt conditions:

- Select Low-Power Mode [20]

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- Select any acceleration range [21]
- Select independent interrupt mode [22]
- Put in Hysteresis and Threshold digits for X, Y and Z axis [23]
- Start data acquisition [8]
- accelerate, roll or tilt the TriBox board while watching the interrupt LED [25]

For Interrupt operation as a function of Threshold and Hysteresis the same as shown in chapter 4.3.2 before applies with one exception. Threshold and Hysteresis can be selected individually for each axis. For Hysteresis set = Zero, the following logic applies, e.g.:

$$LED [25] = 1 \text{ if } LSB_x > Threshold_x \text{ OR } LSB_y > Threshold_y \text{ OR } LSB_z > Threshold_z$$

$$LED [25] = 0 \text{ if } LSB_x < Threshold_x \text{ AND } LSB_y < Threshold_y \text{ AND } LSB_z < Threshold_z$$

For Hysteresis set  $\neq$  Zero, the following logic applies, e.g.:

$$LED [25] = 1 \text{ if } LSB_x > Threshold_x \text{ OR } LSB_y > Threshold_y \text{ OR } LSB_z > Threshold_z$$

$$LED [25] = 0 \text{ if } LSB_x < Hysteresis_x \text{ AND } LSB_y < Hysteresis_y \text{ AND } LSB_z < Hysteresis_z$$

The following example shows how to set up the axis specific Threshold and Hysteresis. The calculation corresponds to the low g operation mode:

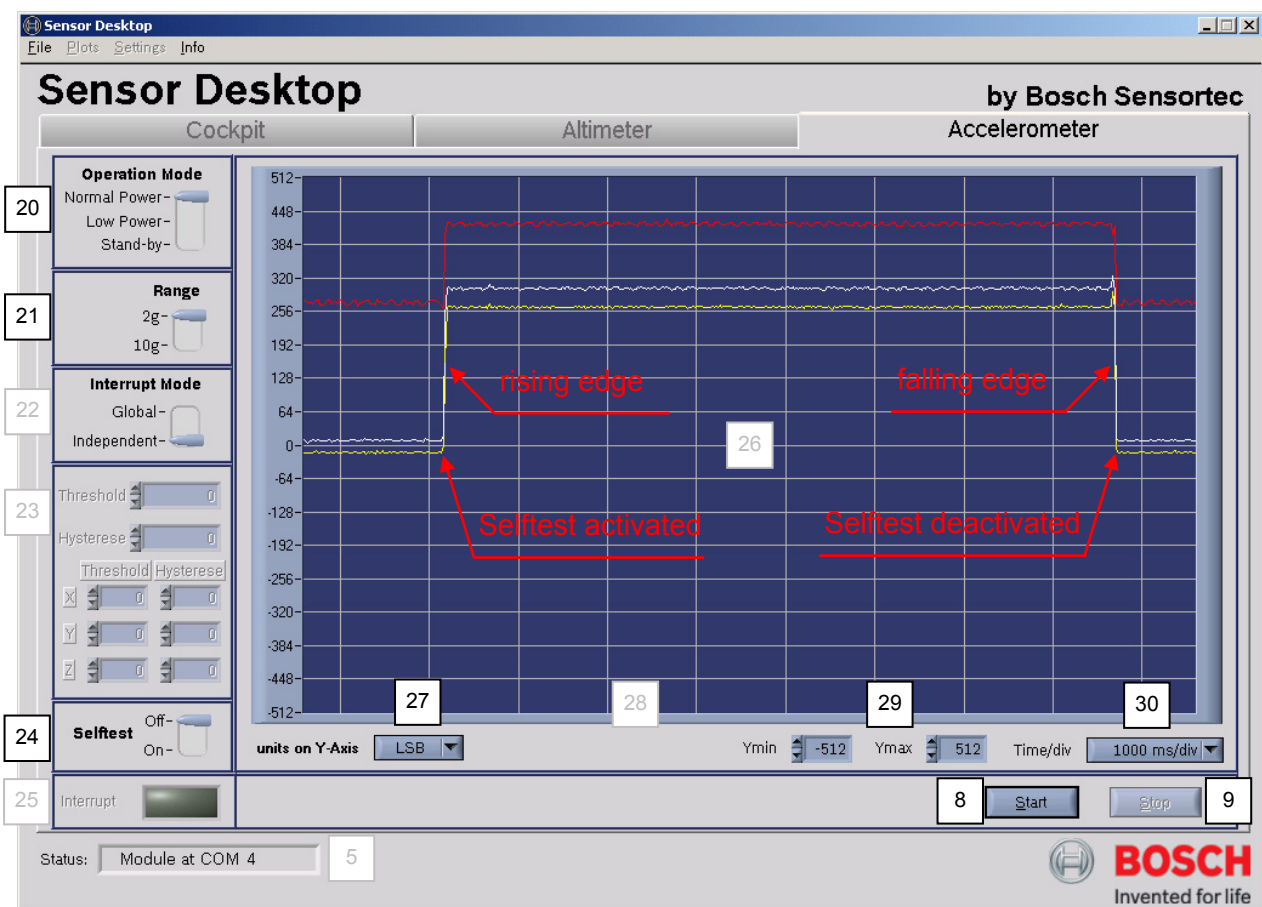
$$\text{Threshold: } 20d = 20 \cdot 16LSB = 320LSB \quad \infty \quad 20 \cdot 64mg = 1.28g$$

$$\text{Hysteresis: } 1d = 320LSB - 1 \cdot 64LSB = 256LSB \quad \infty \quad 1.28g - 1 \cdot 256mg = 1.02g$$


If Hysteresis is equal or above Threshold (LSB values), the interrupt functionality will be disabled. For a total reset of the sensor internal interrupt information just switch to standby mode [20] and continue.

### 4.3.4 SMB365 Selftest

All operation modes of the SMB365 sensor (2g, 10g, normal power, low-power, global and independent interrupt condition) offer full on-chip selftest capability. The selftest acts on all three axes to check all signal evaluation paths of the MEMS simultaneously. This includes the silicon sensing element as well as the ASIC itself. The selftest is realized by a physical deflection of the seismic mass due to an electrostatic force. In operation, it is possible to perform the selftest at any time over the complete life cycle. For more details please refer to the latest sensor related datasheet.






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How to perform a SMB365 Selftest:

- Put the BlueBox in a stable neutral-horizontal position
- Select Operation Mode (example refers to Normal-Power Mode) [20]
- Select acceleration range (example refers to low g Mode) [21]
- Scale ordinate [27], [29] and abscissa [30] (example refers to  $\pm 512$  LSB full scale, in 2g range)
- Start data acquisition [8]
- Wait a few seconds
- Activate Selftest (Selftest On) [24]
- Wait a few seconds
- Deactivate Selftest (Selftest Off) [24]
- Stop data acquisition [9]
- Interpret selftest by comparing LSB signals

A successful test shows a rising edge (signal ad on) while activating the Selftest function and a falling edge (signal subtraction) while activating the Selftest function at every axis on the acceleration signal output screen. Dependent on sensor, acceleration range and axis, the test signal should respond a LSB value within the specified tolerance level in a stable neutral-horizontal position of the board.

Acceleration range	Axis	Successful selftest signal
Low g ( $\pm 2g$ )	X and Y	see related sensor datasheet
	Z	see related sensor datasheet
High g ( $\pm 10g$ )	X and Y	see related sensor datasheet
	Z	see related sensor datasheet

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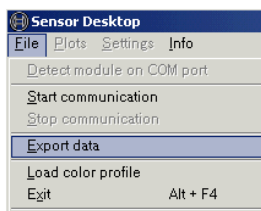
#### 4.4 Sensor Evaluation and Direct Data Export

Using the BST Sensor Desktop software in combination with the BlueBox demo board, it is possible to perform a minor sensor evaluation. This includes both the SMD500 pressure and the SMB365 acceleration sensor simultaneously. For basic evaluation purposes, the software features a so-called online Direct Data Export in \*.txt format via USB or wireless via Bluetooth. The Direct Data Export is unlimited in time. While exporting the Data, for each tab activated (Cockpit, Altimeter or Accelerometer) a corresponding header is automatically added to the \*.txt file. This means that only the active tab corresponding data is recorded.

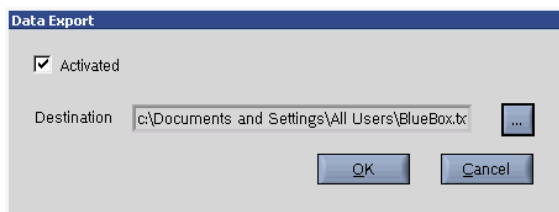
Note: To sample either pressure or acceleration specific signals please use corresponding tab for increased sampling speed.

How to perform a Direct Data Export:

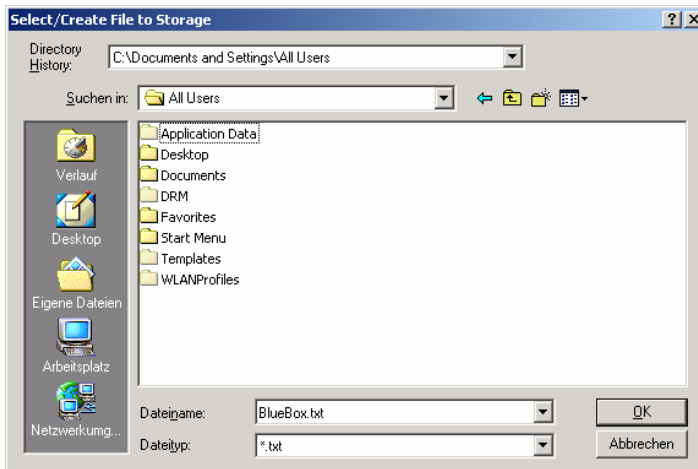
- Open menu “Export Data” from the Sensor Desktop menu bar.



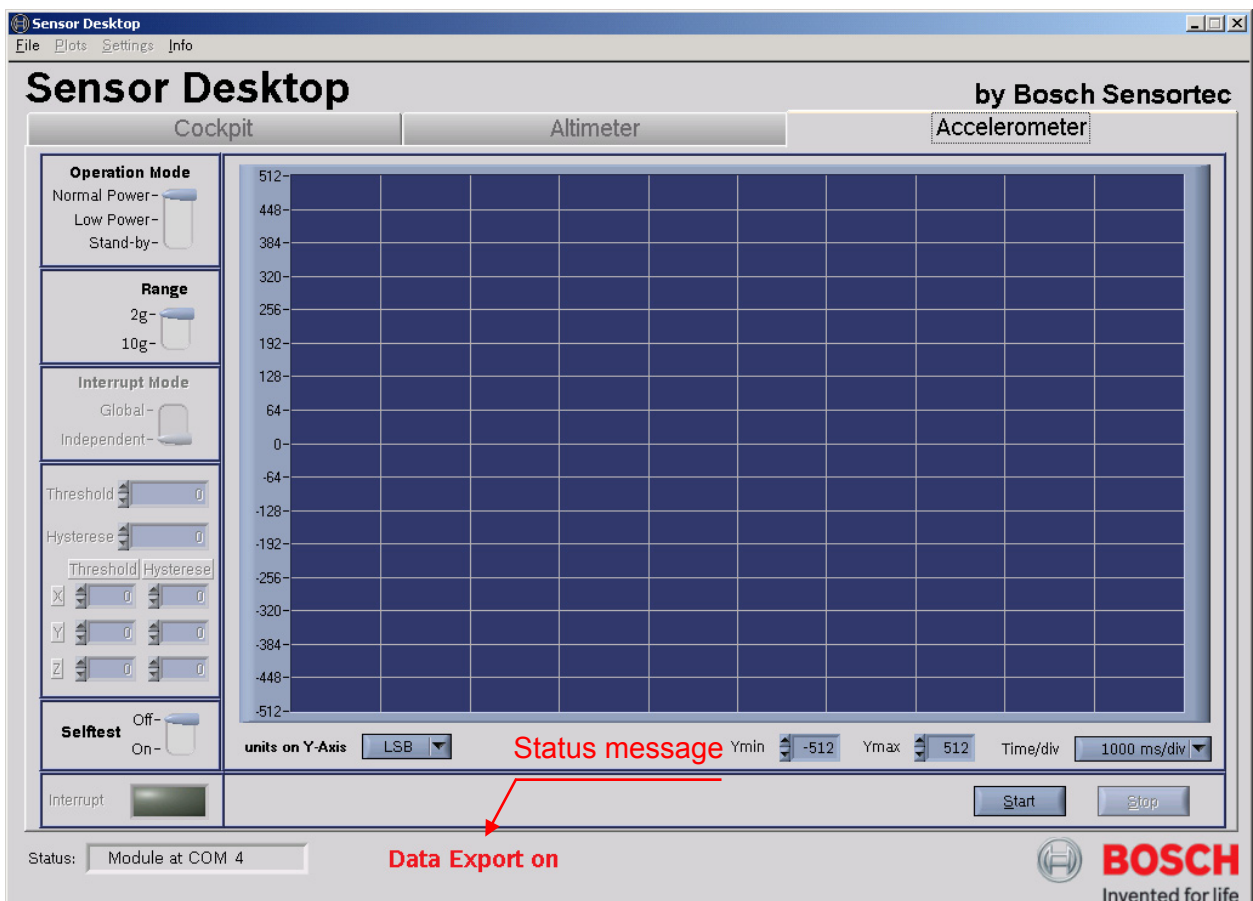
- Check “Activated” box



- Browse and/or create storage folder
- Choose appropriate filename and confirm with “OK”



- If the Direct Data Export is activated correctly, the status message “Data export on” appears at the bottom of the Sesor Desktop software window.




- If the data acquisition is started by a click on “Start”, only the tab-corresponding data will be exported. Regarding the figure above, only acceleration data will be exported.

## Application Note


BlueBox Demo-Board for the digital sensors  
SMB365 (acceleration) and SMD500 (pressure)

- Every time, the tabs (Cockpit, Altimeter and Accelerometer) are switched, the corresponding data export to the \*.txt file stops.
- If started again, a corresponding new header is added to the \*.txt file
- The new sampled data will be automatically appended to the \*.txt file

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### Document History and Modification

Rev. No	Chapter	Description of Modification/Changes	Name	Date
0.0	All	Basic Description	Kult	10-July-06
1.0	All	Review	kult	18-July-06

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<b>1<sup>st</sup> Issue: No. 1.0</b>	Date: 18-July-06	Signature: signed <i>Kult</i> , BST/ENG
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No.:	Date:	Signature:
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No.:	Date:	Signature:
No.:	Date:	Signature:

Department:	Date:	Signature:
BST/ENG	18-July-06	signed <i>Schatz</i> , BST/ENG